Corporate Medical Claim Cost Distributions and Factors Associated with High-Cost Status

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Medical claims cost distributions and factors that relate to these costs were studied among 7796 employees who selected an indemnity medical plan for at least one year during 1985 to 1990. Descriptions for medical claims costs were presented for both single- and multiple-year time periods. Factors that associated with high cost status were studied by using multiple logistic regression models. Employees at or above the top tenth cost percentile were accounted for approximately 80%, 65%, and 58% of the total employees' medical costs to the employer in single-year, 3-year, and 6-year periods, respectively. Bivariate analyses indicated that six of the seven selected demographic variables were significantly related to cost status. When the multivariate models excluded health risk measures, four of the demographic variables and the frequency of health risk appraisal completion were significantly associated with cost status. When the multivariate models included health risk measures, the health risk measures became the dominant predictors of the high-cost status.

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Concern over rapidly increasing health care costs is reaching a historical high. Except for 1973 and 1974, the increase in health care costs has grown faster than the overall economy in 28 of the last 30 years.[1,2] In combination with the economic recession, the growth in employee health benefit expenses is severely limiting corporate profits.[3] According to a 1991 health care benefit survey conducted by A. Foster Higgins & Company, the cost of corporate health benefits, as a percentage of corporate after-tax profit increased, on average, from 26% in 1989 to 45% in 1990.[4]

The expensive health care costs caused by a small segment of the population have been previously documented.[5-8] Using various criteria of high cost and in a variety of populations, the findings of these studies are remarkably similar: the top 1 to 2% of the total population with the highest medical expenditure usually incurs 15 to 30% of the total charge. The top 10 to 15% high-cost workers usually account for 70 to 90% of the total population's costs.[5-8]

The cost distribution during a single year is severely skewed. However, little is known about the distribution of medical claims costs for the same population over multiple years. Although a few studies have calculated the skewness of the medical claims costs from working populations,[9-12] there have been no studies that have performed adequate analyses of a working population's medical claims costs pattern over multiple years.

As health care cost containment becomes more critical to corporations and wellness programs become more and more popular, various work-site health studies have focused on the relationships between employees' health and their respective medical claims expenses.[9–16] A number of studies have used the mean of the costs to demonstrate risk-to-cost associations.[14–16] However, other studies indicated, that using the mean of employees' medical claims was inadequate to identify the statistical relationships between health risks and costs.[9–13] Because of the skewness of the data, some researchers transformed the cost measures prior to performing multivariate analyses.[10,11] These data transformations created disadvantages in the interpretation of their findings.[11–13] Other studies used nonparametric statistical analyses to show the cost differences between high- and low-risk employees.[9,12,13]

A number of health economists have developed complex models to explain the cost variations in randomized population samples.[17–20] Most of these studies were focused on the prediction of medical expenditures using a short-term cost measure.[17–20] Several researchers used a split-sample analysis and developed four-equation models for the cases with different cost status.[17–19] Others also included health measures in their model to predict the personal total health care cost variance among persons.[19,20] As suggested by these studies, no more than 20% of the variance, or multiple r^2, in the short-term health care costs was predictable.[19,20] The predictors used in these models were the most frequently used variables in health surveys, including health status, demographics, and medical plan preferences. An r^2 estimated in one of our previous studies[10] was, in fact, very close to this "maximal predictable r^2" based on their estimation.[19,20] Although these models concluded that 20% of the total personal costs were not truly random and identifiable by health-related measures,[10,19,20] a clear description of the characteristics of the individuals with high medical claims costs status is still absent.[10,17–20] To understand the relationships between health and health care costs, all the issues related to health care costs must be studied.[21]

In the current study, we used the same employee population as our previous studies[9,10] to examine the medical claims cost-related variables. We analyzed the distributions and interrelationships among the employee medical claims costs and determined the criteria to identify the employees with high medical claims costs status. Finally, we generalized the demographic and health factors that associated with high-cost status. These analyses should provide important references for organizations to design their health care cost-containment strategies and useful information for organizations to plan work-site wellness programs.

Methods

Employee Sample

The employee sample in this study was drawn from 10,446 employees who worked for a large manufacturing company for at least 1 year during 1985 through 1990. The company offered both indemnity and health maintenance organization (HMO) plans; however, we focused the study on those employees who selected the indemnity plus during either single- or multiple-year (the employees who continuously selected indemnity plans for all of the respective years) time periods.

Selecting employees only in the indemnity plans was necessary because we were able to access individual claims records from these plans. For the HMO plans, only the prepaid cost rates were available for each person. Of the 10,446 employee population, 7,796 employees selected indemnity plans for at least one year. Thus, the employee sample in the current study included 74.6% of the total population.

Medical Claims Costs

As requested by the employer, the insurance carrier provided the medical claims data. The claims data were originally recorded on a per-claims basis. Each employee's yearly claims were then summed to calculate the total cost per year. Employees' pregnancy and their spouses' and dependents' costs were excluded from the analyses. Annual costs before 1990 were converted to 1990 dollars by using annual medical inflation rates and present value formula.[22,23] The sums of 3- and 6-year totals were then obtained. The cost measures were expressed in nine time periods, including costs of six single-, two 3- and one 6-year period. These measures represented the dollar amount the employer paid for employees' illness and accidents during a given time period, expressed in 1990 dollars. Employees' copays and deductibles were not accounted for in the cost amounts.

Demographic Measures

The demographic measures for this study came from the annual year-end personnel tapes, provided by the administrative company that managed the employer's personnel records. Seven demographic variables were selected for the study, including four dichotomous variables: gender (male/female), medical benefit coverage status (single/family), marital status (married/single), and employee status (active/inactive). We recoded three additional variables into fewer categories for data analyses. The medical plan selection options were combined into four different types according to the plans' premium/deduction features. The majority of employees selected the high-premium/low-deductible option.

We recoded the date of birth and data of hire into categorical variables with close-to-equally distributed sample sizes. Three groups were formed from the date of birth data: born in 1945 or before, born between 1946 and 1955, and born after 1955. The date of hire was categorized into hired before 1970, hired in 1970s, and hired in 1980s. The groupings closely matched the most commonly used categories in other studies.[5–10,24] The recoded variable for date of hire represented three groups with different lengths of employment: employed for 1 to 10 years, 11 to 20 years, and more than 20 years. Similarly, the recoded groups for date of birth represented the three most widely used age groups in health care cost studies: under 35, 35 to 44, and age 45 or over.[24]

Health-Related Measures

Health related measures were collected from voluntary health risk appraisals (HRA). A local wellness center performed blood pressure and total cholesterol screening and administrated the HRA process and feedback. The University of Michigan Fitness Research Center processed the HRA reports. The employer paid for both the screening and HRA costs for all participants in 1985 and again in 1988.

Two types of variables were developed from the HRA data. First, HRA participant status was recorded according to the frequency of completion. Second, four health risk measures were selected from both the self-reported and clinically measured HRA information. Three of these four measures, smoking (current smoker/nonsmoker), self-reported serious medical problems (present/absent), and self-reported absent days (absent more than 5 days/absent 5 days or less), were recorded into dichotomous variables. The reasons for selecting these three measures were (1) smoking is an important public health problem and a major health concern at work sites[25] and (2) absenteeism and medical problems were previously demonstrated as significant predictors of the medical claims costs in the same employee population.[9,10] The fourth health risk measure, cumulative number of high-risk classifications, was developed by counting the times an employee was classified into high-risk status from eight health measures: physical activity level, drug/medication usage, alcohol consumption, two blood pressures, cholesterol, relative weight, and stress level.

The criteria used to define high-risk status for these eight measures were the same reported in the previous studies.[9,10] These measures were included because they were significantly related to medical claims costs,[9] they reflected an employee's health practices, and, to some extent, these high-risk status are preventable.

To ensure the validity of the self-reported data, we studied the relationships between selected HRA measures and available actual records. We found significant associations between self-reported data and actual medical claims costs and recorded illness absent hours. Among the 1308 employees who participated in a HRA in 1988 and who were covered by the indemnity plans from 1985 to 1987, the total 3-year illness claims cost was \$4145 for those who reported serious medical problem in the past 5 years. This can be compared with the \$1102 costs for those employees who did not report any serious medical problem. The odds ratio to be one of the top 10% most costly employees was 4.6 (95% confidence interval: 2.75 to 7.69). Absent records were only available for hourly employees. Of the 1284 hourly employees who participated in a HRA in 1988 and worked for the company in 1987, the company recorded absent hours were significantly related to self-reported absent category ($r = .431$; $P < .001$). The company recorded absent hours for the respondents who reported absent days of 0, 1 to 2, 3 to 5, 5 to 10, 11 to 15, and 16 days or more were 7.3, 11.2, 28.9, 46.2, 68.1, and 75.2, respectively.

High-Cost Status Definition

We first computed cost percentiles for each of the nine time periods. This was necessary to select an appropriate criterion to identify the most expensive employees. We selected a common cut-point to define the workers with high-cost status based on their relationships to the total costs. Although the absolute costs differed from time period to time period, the procedure to select this "critical" percentile ensured a relatively consistent standard definition high-cost employees. Therefore, the same proportion of employees would be classified as high-cost status for each of the nine time periods.

Statistical Analysis

Descriptive statistics were utilized to demonstrate the cost characteristics for the nine time periods. Spearman's rank correlation coefficient (RHO) was calculated to show the correlations of the employees' cost ranks between two different time periods. According to low- and high-cost status identified by the "critical" cost percentile, we computed the odds ratio and 95% confidence intervals. The odds ratio was defined as the ratio of the odds in favor of being in the high-cost status, during one time period if the employee was in the high-cost status in the previous time period, to the odds in favor of being in the high-cost status, if not in the high-cost status in the previous time period.[26] This ratio reflects the likelihood of an employee repeatedly being classified into high-cost status.

χ^2 tests were performed to examine the relationships between the cost status and demographic variables. We calculated the rates of being high-cost according to the demographic conditions. Odds ratios and 95% confidence intervals were calculated to show the odds of being high-cost with the demographic condition present to the odds of being high-cost with the demographic condition absent. Based on these analyses, we selected demographic variables, which were significantly related to the cost measures, as covariate predictors for later multivariate models.

Before the multivariate analyses, the associations between all potential predictors were checked to ensure the models would be free of multicollinearity.[27] Tests of interaction were also performed by examining the strength of the association between a single predictor and the dependent variable according to the level of another predictor.[28] This stratified interaction check ensured that the models were not subject to homogeneity.

Multiple logistic regression models were used to examine the relationships between cost status and HRA participation after adjustment for the demographics. Similar models were developed to use health risk measures to predict cost status among the HRA participants. Adjusted odds ratios of being high-cost according to the health related measures were estimated by controlling for other predictors.[26]

All of the statistical analyses were performed on the Michigan Terminal System using the Osiris Statistical Analysis and Data Management Software System[29] and Michigan Interactive Data Analysis System.[30]

Results

Descriptions of Cost Measures

The descriptions of the cost measures are presented in Table 1. Mean, standard deviation, proportion of employees with zero costs, and cost percentiles are used to show the cost variations. Skewness and kurtosis are computed to exhibit the central tendency of the cost measures. Percentages of the total cost by percentile groups are presented to show the significance of the group-contribution.

As shown in Table 1, the cost measures had wide ranges and large variances with a significant proportion of employees having zero costs in each of the nine time periods. As expected, all of the cost distributions were severely skewed and strongly leptokurtic. For example, a worker could cost the employer as much as $207,619 in a year, equaling 5.1% of the total medical costs from 4,636 employees. Similarly, the most expensive 10% of the employees accounted for 82.3% to 78.8% of the total employee medical claims costs for a single year and 68.4% to 58.3% for multiple years. Based on these descriptions, we selected the top tenth percentile as the "critical" point to identify the high-cost employees for each time period.

There were two observed differences in the cost measures between the single-year and multiple-year time periods. First, the proportion of the employees with zero costs was greater in the single-year periods as compared with the multiple-year periods. Second, the costs by the most expensive segments of the employees became less dominant in the multiple-year periods.

Associations among Cost Measures

Two types of analyses were used to show the associations among cost measures (Table 2). First, RHOs show significant associations among all cost measures ($P < .001$), with a range of .30 to .55 among single years, .38 to .78 between a single- and multiple years, and .83 to .84 among multiple years. The farther apart the years or the fewer the overlapped years, the

TABLE 1
Medical Claim Cost Measures and Frequency Distributions

		Measures by Time Periods*								
		Single Years						Multiple Years		
		1985	1986	1987	1988	1989	1990	1985–1987	1988–1990	1985–1990
Overall cost measures										
Number of employees	N	5,153	5,311	4,704	4,362	4,636	4,838	3,773	3,447	2,673
Employees with zero costs	N	2,204	2,276	2,072	1,867	2,128	2,332	791	785	299
	%	42.8	42.9	44.0	42.8	45.9	48.2	21.0	22.8	11.2
Total cost	$	4,122,364	4,364,458	4,647,859	4,529,357	4,085,656	3,639,115	9,886,796	8,964,141	13,129,255
Average cost†	$	800	822	988	1,038	881	752	2,620	2,601	4,912
Standard deviation	$	3,286	4,049	5,187	4,967	4,883	3,813	8,042	10,158	12,713
Skewness		11.6	25.9	19.7	19.5	25.0	19.3	12.6	22.3	10.2
Kurtosis		186.7	1,032.9	528.0	590.1	901.4	536.3	252.1	747.4	153.0
Cost percentiles										
Maximal individual	$	79,391	191,553	171,902	188,393	207,619	129,798	224,417	398,535	242,270
Top 1%	$	11,562	12,150	15,703	19,346	13,512	12,105	31,646	32,570	44,200
Top 10%	$	1,517	1,637	1,808	1,872	1,466	1,291	6,670	6,355	11,867
Top 20%	$	564	595	681	741	568	493	3,013	2,597	6,488
Top 50%	$	52	50	47	55	31	14	482	459	1,366
% of total cost by cost percentiles										
Maximal individual	%	1.9	4.3	3.6	4.1	5.1	3.6	2.3	4.4	1.8
Top 1%‡	%	31.4	32.3	36.5	34.0	37.0	36.0	22.7	25.5	19.2
Top 10%	%	80.0	78.8	80.8	79.9	82.3	82.1	64.9	68.4	58.3
Top 20%	%	91.1	90.9	92.0	91.2	92.5	92.6	82.3	84.0	76.0
Top 50%	%	99.7	99.7	99.8	99.8	99.9	99.9	97.8	98.1	95.9

* The cost measures are the amounts that the employer paid for the employees who selected the indemnity plans. The costs represent 1990 dollar value and exclude pregnancy costs. The cost measures for multiple years are limited to the employees who continuously selected the indemnity plans for all of the respective years within the time period.

† Based on total employees, including employees with zero costs.

‡ From top 1% to top 50%, the percentages of total cost are accumulated.

TABLE 2
Associations between Cost Measures* of Any Two Time Periods

		Measures by Time Periods†							
		Single Years					Multiple Years		
		1986	1987	1988	1989	1990	1985–1987	1988–1990	1985–1990
1985	RHO‡	.48	.41	.38	.33	.30	.71	.38	.58
	Odds Ratio	5.2	4.0	3.6	3.3	2.5	18.4	3.8	11.5
	(95% CI)§	(4.2–6.5)	(3.1–5.2)	(2.7–4.7)	(2.5–4.5)	(1.8–3.5)	(14.3–23.6)	(2.8–5.2)	(8.5–15.6)
1986	RHO		.52	.45	.39	.36	.76	.44	.65
	Odds Ratio		5.2	3.3	3.5	3.0	24.5	4.1	10.8
	(95% CI)		(4.1–6.6)	(2.5–4.3)	(2.6–4.6)	(2.2–4.1)	(18.9–31.5)	(3.0–5.5)	(8.0–14.5)
1987	RHO			.53	.44	.37	.77	.50	.68
	Odds Ratio			5.6	4.1	3.6	21.0	4.4	11.9
	(95% CI)			(4.4–7.1)	(3.1–5.3)	(2.8–4.8)	(16.3–27.0)	(3.2–5.8)	(8.8–16.0)
1988	RHO				.54	.44	.52	.76	.68
	Odds Ratio				6.6 (5.1–8.4)	4.8	4.9	22.5	15.4
	(95% CI)					(3.7–6.3)	(3.7–6.4)	(17.2–29.4)	(11.4–20.7)
1989	RHO					.50	.44	.78	.66
	Odds Ratio					7.6	5.5	30.0	15.8
	(95% CI)					(6.0–9.6)	(4.1–7.3)	(22.9–39.3)	(11.8–21.2)
1990	RHO						.38	.74	.62
	Odds Ratio						3.4	25.8	14.2
	(95% CI)						(2.5–4.7)	(19.8–33.7)	(10.6–19.0)
1985–1987	RHO							.84	.83
	Odds Ratio							4.8	41.8
	(95% CI)							(3.5–6.6)	(30.0–58.4)
1988–1990	RHO								.84
	Odds Ratio								56.8
	(95% CI)								(40.6–79.4)

* Only includes the employees who were covered by the indemnity plans during both time periods.
† All RHOs and odds ratios are statistically significant: $P < .01$.
‡ Spearman's coefficient of rank correlation.
§ Odds ratio and 95% confidence level, the ratio of the odds of being high-cost status in both time periods.

lower the RHO coefficients. In addition, the limited variation in the RHOs between the 3-year total and any of the single years (RHO, from .71 to .78) or between the 6-year total and each of 3-year total (RHO, from .83 to .84) suggests that the cost ranks from an inclusive time period contributed almost equally to the total cost ranking for that time period.

Second, as shown by the odds ratio (OR) and the 95% confidence intervals (CI), the odds for an employee repeatedly being classified into the high cost status was significantly high, ranging from 3.3 to 56.8 ($P < .001$). Similar to RHOs, the odds ratios are greater between two closer time periods than between two further-apart time periods. The highest odds ratios are between the 6-year and two 3-year periods (OR, 41.8 and 56.8, respectively). The ORs of being high-cost between 3-year periods and the inclusive single-years are also consistently high, ranging from 18.4 to 30.0.

Thus, both the RHO and OR analyses suggest that an employee's high-cost status is highly predictable from one year to the next. It shows that once an employee obtained high-cost status in one year, he or she tended to remain in that high-cost status in other years.

Association between Costs and Demographics

Table 3 presents the numbers and percentages of employees being high cost according to demographic conditions and their odds ratios and 95% confidence intervals.

As indicated by the χ^2 tests, the employees who (1) were born before 1946, (2) selected high-premium (low deductible) medical plans, and (3) had inactive employee status were more likely to be high-cost than their cohorts in all nine time periods. Except in 1990, currently married employees had significantly lower high-cost status than those who were not currently married. The employees with single medical benefit coverage status and hired before 1970 had a significantly higher percent of high-cost status in six of the nine time periods. Gender was not significantly related to being high-cost, except for 1986 and during the total 6-year period (when a higher percent of women were classified as high cost).

The odds ratios and 95% confidence intervals provide criteria to compare the strength of the bivariate associations between each of demographic variables and cost status. The selection of medical plans (high premium-low deductible vs low premium-high deductible) had the strongest associations with cost status

TABLE 3
Associations between Cost and Demographic Measures

Demographic Status	Numbers and Percentages of High-Cost Employees by Time Periods								
	Single Years						Multiple Years		
	1985 (N = 5153)	1986 (N = 5311)	1987 (N = 4704)	1988 (N = 4362)	1989 (N = 4636)	1990 (N = 4838)	1985–1987 (N = 3773)	1988–1990 (N = 3447)	1985–1990 (N = 2673)
Gender									
Male	385 (9.6%)*	374 (9.2%)	340 (9.6%)*	315 (9.8%)*	333 (9.9%)*	341 (9.7%)*	280 (9.5%)*	245 (9.4%)*	195 (9.3%)
Female	130 (11.4%)*	156 (12.7%)	130 (11.1%)*	123 (10.8%)*	130 (10.3%)*	142 (10.8%)*	97 (11.6%)*	99 (11.6%)*	72 (12.6%)
OR (95% CI)	1.2 (1.0–1.5)	1.4 (1.2–1.8)	1.2 (0.9–1.5)	1.1 (0.9–1.4)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	1.3 (1.0–1.6)	1.3 (1.0–1.6)	1.4 (1.0–1.9)
Date of birth†									
After 1955	127 (8.8%)	122 (7.6%)	118 (7.9%)	109 (8.0%)	124 (8.1%)	132 (7.9%)	67 (7.0%)	77 (7.7%)	42 (6.9%)
1946–1955	143 (8.1%)	163 (9.0%)	158 (10.1%)	141 (9.6%)	147 (9.3%)	147 (8.9%)	116 (8.9%)	112 (9.3%)	86 (9.1%)
OR (95% CI)	0.9 (0.7–1.2)	1.2 (0.9–1.5)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	1.2 (0.9–1.5)	1.2 (0.9–1.5)	1.3 (0.9–1.8)	1.2 (0.9–1.7)	1.3 (0.9–2.0)
Before 1946	245 (12.6%)	245 (12.9%)	194 (11.8%)	188 (12.3%)	192 (12.6%)	204 (13.5%)	194 (12.8%)	155 (12.4%)	139 (12.4%)
OR (95% CI)	1.5 (1.2–1.9)	1.8 (1.4–2.3)	1.6 (1.2–2.0)	1.6 (1.3–2.1)	1.6 (1.3–2.1)	1.8 (1.5–2.3)	1.9 (1.5–2.6)	1.7 (1.3–2.3)	1.9 (1.3–2.7)
Date of hire†									
Since 1980	146 (8.2%)	186 (8.7%)	193 (9.4%)*	187 (9.5%)*	220 (9.6%)	229 (8.9%)	112 (9.1%)*	136 (9.0%)	82 (9.5%)
1970–1979	215 (10.1%)	211 (10.5%)	177 (10.7%)*	147 (9.8%)*	136 (9.1%)	155 (10.7%)	160 (10.2%)*	119 (9.9%)	108 (9.7%)
OR (95% CI)	1.3 (1.0–1.6)	1.2 (1.0–1.5)	1.2 (0.9–1.4)	1.0 (0.8–1.3)	0.9 (0.8–1.2)	1.2 (1.0–1.5)	1.1 (0.9–1.5)	1.1 (0.9–1.4)	1.0 (0.8–1.4)
Before 1970	154 (12.4%)	133 (11.4%)	100 (10.0%)*	104 (11.6%)*	107 (12.4%)	99 (12.1%)	105 (10.9%)*	89 (12.2%)	77 (11.2%)
OR (95% CI)	1.6 (1.3–2.0)	1.3 (1.1–1.7)	1.1 (0.8–1.4)	1.2 (1.0–1.5)	1.3 (1.0–1.7)	1.4 (1.1–1.8)	1.2 (0.9–1.6)	1.4 (1.1–1.9)	1.2 (0.9–1.7)
Medical plan selection									
Low premium	16 (3.5%)	14 (2.8%)	13 (2.0%)	23 (3.2%)	26 (3.3%)	46 (4.7%)	18 (3.5%)	29 (4.1%)	25 (4.9%)
High premium	499 (10.6%)	516 (10.7%)	457 (11.2%)	415 (11.4%)	437 (11.4%)	437 (11.3%)	359 (11.0%)	315 (11.5%)	242 (11.2%)
OR (95% CI)	3.3 (2.0–5.4)	4.2 (2.5–7.2)	6.1 (3.5–10.7)	3.9 (2.5–6.0)	3.8 (2.5–5.7)	2.6 (1.9–3.6)	3.4 (2.1–5.6)	3.0 (2.1–5.6)	2.5 (1.6–3.8)
Employee status									
Active	420 (9.1%)	472 (9.6%)	444 (9.9%)	336 (9.1%)	382 (9.4%)	430 (9.5%)	348 (9.6%)	306 (9.4%)	230 (9.1%)
Inactive	95 (17.6%)	58 (15.0%)	26 (12.9%)	102 (15.0%)	81 (14.2%)	53 (16.4%)	29 (20.7%)	38 (18.5%)	37 (24.3%)
OR (95% CI)	2.1 (1.7–2.7)	1.7 (1.2–2.2)	1.4 (0.9–2.1)	1.8 (1.4–2.2)	1.6 (1.2–2.1)	1.9 (1.4–2.5)	2.5 (1.6–3.8)	2.2 (1.5–3.2)	1.9 (1.4–2.5)
Marital status									
Married	376 (9.0%)	394 (9.3%)	334 (9.1%)	310 (9.0%)	330 (9.1%)	355 (9.5%)*	265 (8.6%)	248 (9.0%)	194 (8.8%)
Single	139 (13.9%)	136 (12.5%)	136 (13.1%)	128 (14.0%)	133 (13.0%)	128 (11.5%)*	112 (16.0%)	96 (13.7%)	73 (15.5%)
OR (95% CI)	1.6 (1.3–2.0)	1.4 (1.1–1.7)	1.5 (1.2–1.9)	1.7 (1.3–2.1)	1.5 (1.2–1.8)	1.2 (1.0–1.5)	2.0 (1.6–2.6)	1.6 (1.3–2.1)	1.9 (1.4–2.5)
Family status									
Family	408 (9.5%)	428 (9.6%)*	378 (9.6%)*	346 (9.5%)	366 (9.5%)	392 (9.7%)*	309 (9.4%)	277 (9.3%)	222 (9.3%)
Single	107 (12.5%)	102 (11.7%)*	92 (11.7%)*	92 (12.8%)	97 (12.6%)	91 (11.5%)*	68 (14.2%)	67 (14.2%)	45 (15.7%)
OR (95% CI)	1.4 (1.1–1.7)	1.3 (1.0–1.6)	1.3 (1.0–1.6)	1.4 (1.1–1.8)	1.4 (1.1–1.8)	1.2 (1.0–1.5)	1.6 (1.2–2.1)	1.6 (1.3–2.1)	1.8 (1.3–2.6)

* Not significant as tested by χ^2 tests ($P > .05$).
† To calculate the odds ratios, the first (upper) group was used as reference (demographic condition absent).

(OR, 2.5 to 6.1), followed by inactive versus active employee status (OR, 1.4 to 2.5), date of birth (before 1946 vs after 1955; OR, 1.5 to 1.9), marital status (single vs married; OR, 1.2 to 2.5), and medical benefit coverage status (single vs family; OR, 1.2 to 1.8).

The relationships between cost status and employee termination and medical plan switching from indemnity to HMO were also studied, but not presented in Table 3. The average annual termination and medical plan switching rates between 1986 to 1990 were 4.84 and 9.43 for low-cost employees and 5.71 and 8.08 for high-cost employees, respectively. Although no statistically significant differences were found between the high- and low-cost employees, in any given year, the trends indicate an interesting pattern.

Association between Cost Status and HRA Participation

Pearson correlations among the demographic variables were calculated before multivariate analyses. Date of birth and date of hire were significantly related ($r = .66$; 95% CI, .65 to .67), so were the medical benefit coverage and marital status ($r = .63$; 95% CI, .61 to .64). Based on these strong correlations, we eliminated date of hire and medical benefit coverage status as potential predictors to avoid multicollinearity. Thus, four demographic variables, date of birth, medical plan selection, employee status, and marital status, were selected in the multiple logistic regression models as covariate predictors.

HRA completion frequency was used as a primary predictor in the models. No strong interactions were detected among all of the five predictors. Adjusted odds ratios estimated from the regressions for each predictor and the total variance explained by the combination of all predictors are presented in Table 4.

As shown in Table 4, the total variance explained by the multiple years'

TABLE 4

Relation of Demographic Variables and HRA Participations to High-Cost Status Estimated from Multiple Logit Regression Models

Predictors	Adjusted Odds Ratios* by Time Periods: Single Years						Multiple Years		
	1985 (N = 5153)	1986 (N = 5311)	1987 (N = 4704)	1988 (N = 4362)	1989 (N = 4636)	1990 (N = 4838)	1985–1987 (N = 3773)	1988–1990 (N = 3447)	1985–1990 (N = 2673)
Date of birth									
After 1955	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1946–1955	1.0	1.3	1.5	1.4	1.3	1.2	1.5	1.4	1.5
	(0.8–1.2)	(1.1–1.5)	(1.2–1.7)	(1.1–1.6)	(1.1–1.5)	(1.0–1.4)	(1.2–1.8)	(1.1–1.7)	(1.2–1.9)
Before 1946	1.7	2.0	1.9	1.4	1.7	1.9	2.4	1.8	2.1
	(1.5–1.9)	(1.7–2.3)	(1.6–2.2)	(1.1–1.6)	(1.5–2.0)	(1.6–2.2)	(2.1–2.8)	(1.5–2.2)	(1.8–2.6)
Medical plan selection									
Low premium	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
High premium	3.2	3.9	5.6	3.7	3.6	2.5	2.5	3.2	1.9
	(2.9–3.5)	(3.6–4.4)	(5.0–6.2)	(3.3–4.0)	(3.3–4.0)	(2.2–2.7)	(2.2–2.8)	(2.8–3.6)	(1.7–2.2)
Employee status									
Active	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Inactive	2.0	1.5	1.2	1.7	1.6	2.5	2.4	2.1	3.0
	(1.6–2.4)	(1.1–2.0)	(0.8–1.8)*	(1.3–2.1)	(1.3–2.1)	(2.2–2.8)	(1.5–3.7)	(1.4–3.0)	(2.0–4.4)
Marital status									
Married	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Single	1.6	1.4	1.5	1.6	1.5	1.2	2.2	1.5	1.9
	(1.3–1.9)	(1.2–1.7)	(1.2–1.9)	(1.3–2.0)	(1.2–1.8)	(1.0–1.5)	(1.7–2.7)	(1.2–1.9)	(1.5–2.5)
HRA completion frequency									
Two HRAs	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
One HRA	1.2	1.2	1.3	1.0	1.0	0.8	1.3	1.0	1.0
	(1.0–1.4)	(1.0–1.4)	(1.1–1.6)	(0.8–1.2)†	(0.9–1.2)†	(0.7–1.0)†	(1.1–1.5)	(0.8–1.2)†	(0.8–1.2)
No HRA	1.3	1.3	1.7	1.2	1.0	1.0	1.5	1.2	1.4
	(1.1–1.5)	(1.2–1.5)	(1.4–1.9)	(1.0–1.4)†	(0.9–1.2)†	(0.8–1.1)†	(1.3–1.8)	(1.0–1.4)†	(1.2–1.7)
% of variance explained‡	2.8	2.4	3.4	3.3	2.8	2.4	4.1	3.7	4.1

* Estimated from multiple logit regression models by adjusting other predictors' effects on cost status.

† Not significant as tested by χ^2 tests ($P > .05$).

‡ Total variances explained by the combinations of all predictors on cost-status. (All models are statistically significant; $P < .001$).

models (3.7 to 4.1%) were greater than the variance explained by single years' (2.4 to 3.4%). Adjusted for the demographic conditions, the HRA completion frequency was significantly related to the cost status from 1985 to 1987, but not 1988 to 1990. The employees who did not complete a HRA were more likely to have been high-cost during each of the first 3 years (1985 to 1987) and during each of the multiyear time periods.

As compared with the unadjusted odds ratios from the bivariate analyses (shown in Table 3), the adjusted odds ratio in the multivariate models were higher for date of birth, but lower for employee status and medical plan selections, and nearly identical for marital status.

Association between Health Practices and Cost Status

When we required the availability of the health practices and cost data, we focused on two employee groups with reduced sample sizes: the 1985 HRA participants and the 1988 HRA participants. No strong interactions were found among all potential pre-

TABLE 5

Relation of Demographic and Health Practice Measures to High-Cost Status Estimated from Multiple Logit Regression Models

Predictors	Adjusted Odds Ratios* by Time Periods: 1985 HRA Participants			1988 HRA Participants		
	1985–1987 (N = 1962)	1988–1990 (N = 1597)	1985–1990 (N = 1421)	1985–1987 (N = 1308)	1988–1990 (N = 1395)	1985–1990 (N = 1060)
Date of birth						
After 1955	1.0	1.0	1.0	1.0	1.0	1.0
1946–1955	1.6	1.3	1.8	1.9	0.9	1.1
	(1.1–2.2)	(1.0–1.8)†	(1.3–2.5)	(1.3–2.8)	(0.6–1.3)†	(0.7–1.7)†
Before 1946	2.6	1.2	1.6	2.5	0.9	1.1
	(2.1–3.4)	(1.0–1.6)†	(1.2–2.2)	(1.9–3.4)	(0.6–1.2)†	(0.7–1.5)†
Medical plan selection						
Low premium	1.0	1.0	1.0	1.0	1.0	1.0
High premium	2.4	1.3	2.1	1.7	3.3	4.2
	(1.9–2.9)	(1.0–1.6)†	(1.7–2.7)	(1.3–2.2)	(2.6–4.1)	(3.2–5.5)
Employee status						
Active	1.0	1.0	1.0	1.0	1.0	1.0
Inactive	1.8	1.4	1.4	1.9	1.6	1.9
	(0.8–4.1)†	(0.7–2.6)†	(0.7–2.9)†	(0.4–9.9)†	(0.8–3.2)†	(0.9–4.2)†
Marital status						
Married	1.0	1.0	1.0	1.0	1.0	1.0
Single	1.7	1.2	1.3	1.9	1.3	1.3
	(1.2–2.6)	(0.8–1.9)†	(0.8–2.1)†	(1.2–3.2)	(0.9–2.1)†	(0.7–2.4)†
HRA completion frequency						
Two	1.0	1.0	1.0	1.0	1.0	1.0
One	1.2	0.8	0.8	1.0	0.9	0.9
	(0.9–1.5)†	(0.6–1.1)†	(0.6–1.1)†	(0.7–1.5)†	(0.6–1.3)†	(0.5–1.5)†
Absenteeism						
<6 days	1.0	1.0	1.0	1.0	1.0	1.0
6 days or more	2.8	1.5	2.6	2.3	2.7	4.0
	(2.0–4.1)	(1.0–2.4)†	(1.6–4.1)	(1.4–3.9)	(1.6–4.5)	(2.3–6.5)
Medical problems						
Absent	1.0	1.0	1.0	1.0	1.0	1.0
Present	2.9	2.7	3.5	4.2	1.7	3.2
	(2.2–3.9)	(1.9–3.7)	(2.5–5.0)	(3.1–6.0)	(1.2–2.6)	(2.1–4.8)
No. of risk factors						
Two or fewer	1.0	1.0	1.0	1.0	1.0	1.0
More than two	1.6	1.6	2.1	1.4	1.8	2.3
	(1.1–2.3)	(1.1–2.3)	(1.4–3.1)	(0.9–2.1)†	(1.2–2.6)	(1.4–3.6)
Smoking status						
Nonsmokers	1.0	1.0	1.0	1.0	1.0	1.0
Current smokers	1.4	1.6	1.3	1.1	2.2	1.7
	(1.0–1.8)†	(1.2–2.1)	(0.9–1.9)†	(0.7–1.6)†	(1.6–3.0)	(1.2–2.6)
% of variance explained‡	11.5	5.0	10.6	10.2	7.5	12.8

* Estimated from multiple logit regression models by adjusting other predictors' effects on cost status.
† Not significant as tested by χ^2 tests ($P > .05$).
‡ Total variances explained by the combinations of all predictors on cost-status.

dictors with cost status. The results of the logistic regression analyses are presented in Table 5.

Compared with the previous models without health practice predictors, the total variance explained by the new models was higher. Several predictors that significantly predicted cost status in the previous models became insignificant in the new models. HRA completion frequency (nonparticipants who were the most expensive were excluded) and employee status were no longer related to cost status in any time periods, date of birth was not significantly related to cost status in 1988 to 1990, and marital status was related to cost status only in 1985 to 1987. However, medical plan selection remained a strong predictor in the new models during five of the six time periods.

Of the four health-related measures selected in the new models, self-reported medical problems, after adjustment for other predictors, was significantly related to cost status during each of the time periods. Adjusted odds ratios for self-reported absenteeism and total number of risk factors were significant in five of the six time periods. Smoking status was significantly related to cost status in three of six time periods.

The significant contribution of the health risk measures in predicting cost status provides evidence that the health-related measures should be added to the dominant predictors of being high-cost along with the demographic measures mostly often used in medical insurance premium accounting systems.

Discussion

This study presents a comprehensive description of medical claims cost measures for a corporation during a 6-year period. No work-site health studies have demonstrated the patterns of medical claims costs as detailed as the current study. One aspect of the current findings, that a small segment of employees dominate the employer-paid medical claims costs, is similar to the findings from other studies or from national surveys.[5-8] The findings suggested that helping those employees with high-cost status use the medical care system effectively should be an important worksite health care cost containment strategy.

Cost percentiles were used to define the employees with high-cost status in a given time period. We believe, using cost percentiles, instead of using the mean or median to define cost status, provides a more meaningful tool to analyze worksite medical claims costs. This finding is important since the top 10% most costly employees accounted for 58 to 82% of the employee medical claims costs in a single time period.

Among those employees who selected the indemnity medical plans, six of the seven demographic variables were significantly associated with cost status in bivariate relationships and four of these variables (date of birth, medical plan selections, marital status, and medical benefit coverage status) remained as significant predictors in multivariate models. These findings reveal that the demographic measures are important factors related to employer medical care expenses.

The multivariate analyses also indicated that the employees who completed HRAs were less likely to have high-cost status (see Table 4). This finding is partially in agreement with the findings of Lynch et al,[13] who compared the top 10% most expensive employees between responders (HRA) and nonresponders and found "nonresponders had greater claims costs than responders." In other words, if the same cost standard (the total employees) is used to define the top 10% most expensive employees, there is a higher proportion of nonresponders classified into the most expensive cost status. This finding supports the notion that work-site health promotion program participants (HRA participants in this example) associate with lower medical claims costs.

One of the most significant findings of the current study is that the high-cost employees (top 10%) can be predicted from health-risk measures, including smoking status, total number of health risk factors, absenteeism, and medical problems. These health-risk measures were stronger predictors than the demographics in our multivariate models. However, current smoking status and number of risk factors in 1988 were not significantly related to retrospective cost status during 1985 to 1987. This finding supports the notion that personal health practices have a strong prospective than retrospective effect on medical claims costs.

Another significant finding is that the health risk measures (the variables most frequently emphasized in the field of health promotion) can explain a limited amount of the variance in prospective estimates of health care costs. The recognition of this limitation may be critical to the future of work-site health promotion/wellness programs. It may prevent an overestimation of program-related savings on employer health care payments and help to set realistic goals for health care cost containment.

Several limitations should be considered when interpreting the current findings. First, the results of the analyses on medical claims costs were limited to the employees who selected indemnity medical plans, whereas employees who selected HMOs were excluded. As several studies suggest, differences exist between employees who select indemnity plans versus those who select HMO plans.[31-33]

Second, in the final multiple regression models we used cost data from multiple years and health practices data from the HRA. The criteria of multiple-year indemnity plan selections and HRA participation resulted in significant reductions of sample sizes; thus, a possible sampling bias might have been created. For example, employees who switched medical plans between HMO and indemnity were excluded from our analyses because of not participating consecutively in the plans for multiple years. It has been shown that those employees who switch plans are also often associated with high medical care utilization.[34] Furthermore, HRA participants are believed to be healthier than nonparticipants.[35] In the present study, among the employees who were in indemnity plans for 6 consequent years, only 9.2% of the HRA participants were classified into high-cost status, whereas 12.8% of non-HRA participants had high cost status. This finding demonstrates that the final samples from HRA participants were biased in terms of missing some of the most expensive employees from the non-HRA participants.

Third, the total variance explained by our final models was 12.8%, which was less than the maximal expectation reported from other studies.[10,19,20] The dependent variable to be predicted in those previous studies was the continuous variable of cost averages with or without data transformation, whereas in the current models we tried to predict dichotomous cost-status and to identify the 10% most expensive employees. The differences in total explainable variances between our current models and the models from other studies are likely due to the difference in dependent variable type and meaning of the measurements.

Fourth, the costs studied were the total medical claims costs without pregnancy cost and without differentiating costs by diagnosis. Because lifestyle, environment, and heredity all have different contributing effects according to differing disease categories, a diseases-specified cost study may reduce some random errors in estimating the risk-cost relationships. For example, we found that the smoking status was significantly related to medical cost-status of 1988 to 1990, but not related to the cost status of 1985 to 1987. Further analysis to divide high-cost workers by causes or major disease categories will help us to explain why the findings were different during the two time periods. In addition, we will continue our current risk-cost relationship studies on various causes or diseases, such as pregnancy costs, cardiovascular diseases' costs, mental health costs, etc.

Fifth, the cost status, in this paper, was determined by the top tenth percentile in cost to the employer. Although this selection is based on cost distribution, the selection is still artificial. A dollar difference could put an employee into a higher or lower cost category, which may or may not affect the final conclusion. However, because our sample size was over 1000 in any model, we expect that the effects of this artificial cost status determination were minimal.

Sixth, the costs we studied were employer payment, not total employee medical expenses. This restriction precludes a study of the medical costs of an employee who claimed his or her medical expense at his or her spouse's work site or through some other mechanism. We were studying the relationship between employees' health-related measures and their costs to the employer, not the employee medical expenses.

In summary, this study presents a comprehensive description of medical claims costs in both single and multiple years. This study reveals that a small segment of employees are responsible for the majority of the employer's employee medical claims payments. This study also demonstrates that health risk measures, along with demographic variables significantly predict, prospectively, the small segment of the most expensive employees.

The findings of the current study provide strong evidence that the most expensive employees are identifiable through health risk appraisal programs. It suggests that HRA is not only a tool for health promotion and risk reduction but also a tool for medical care cost containment.

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Middle Age: The Rumored Black Box

According to the picture of human development drawn by traditional scientific literature, after a busy childhood and adolescence young adults launch their careers and social lives and then stride into a black box, from which they hobble some forty years later to face a darkly eventful senescence. According to popular literature, what takes place inside the box is an anticlimactic, unsatisfying, and even traumatic march over the hill and toward the grave—or worse, the nursing home. This scenario complements the anecdotes that often figure in conversations about middle age: that friend of a friend whose lifetime investment in career and family went up in the flames of a passion for the au pair, or that second cousin rumored to have gone off the deep end during the "change of life" when the kids left for college.

So entrenched is the idea that middle age is bad or boring or both that the almost 80 million members of the graying Baby Boom generation won't use the term except in referring to Ozzie and Harriet Nelson or Ward and June Cleaver.

From "Midlife Myths," by W. Gallagher in *The Atlantic*, May 1993, pp 57–68