Research Application

Emerging Research: A View From One Research Center

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INTRODUCTION

The mission of the Health Management Research Center, as a faculty member's research laboratory at the University of Michigan, is to study the longitudinal links between health behaviors, health status, productivity, health care costs, and quality of life using the worksite as the population base. Beginning with its establishment in 1976, the center has collected healthcare utilization, productivity, or lifestyle behavior data on over 2,000,000 individuals. The power and uniqueness of the database comes from the 7 to 18 years of longitudinal data from the corporate consortium members. Current corporate consortium members include General Motors, United Auto Workers–General Motors (UAW-GM), Bank One, Steelcase, the Progressive Corporation, Honeywell-General Electric, Genesys Health System, Australian Health Management Group, Xerox, and Detroit Diesel.

The 1970s presented a limited opportunity to use worksite populations as an environment where important lifestyle choices could be made to enhance quality of life for individuals and organizations. The center used the opportunity to cooperate with several companies in establishing worksite health promotion programs. That early experience identified the extent of the potential return-on-investment for individuals and corporations.

The 1980s were a time of experimentation with different strategic plans for worksite health promotion, which led to a broadening of the concept. As the private sector began to assume the worksite programming responsibilities, we at the center shifted our emphasis to decision support, measurement, and evaluation. These 10 years led to the early stages of data collection and to the establishment of our longitudinal database, the Integrated Health Management System.

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The 1990s led to expansion of the analysis system and a formal organization of the consortium of corporate partners for the long-term study of worksite programs. The multifaceted nature of worksite health drove the center's researchers to address the needs of all stakeholders (employee, employer, insurer, and provider) interested in the costs and benefits of health and productivity. Our research became focused on the quantitative relationships between health behaviors and health and productivity and the benefits of high risk reduction and low risk maintenance and how these relationships were incorporated into program strategies.

As we enter the decade of 2000, new discoveries are emerging from our work. The growth of the database in number of people as well as years of observation, and the advances in data analytical techniques as well as computer technology, are helping us detect new trends. Although we have observed some of these trends over many years, we need to caution the reader that these are just trends. We need to subject these trends to continuous and rigorous internal review and to external peer review.

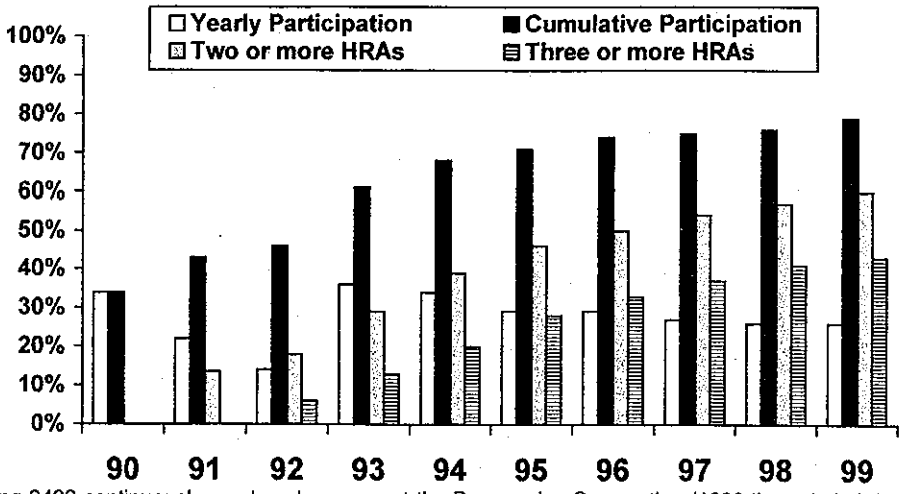
The purpose of this paper is to review recent and current findings, illustrate key emerging research trends, and identify the critical research questions likely to influence our future work. With respect to the emerging research findings from our data, we are reporting them here in the interest of sharing our current work with the broader research, clinical, and practitioner communities. We are observing trends in the following areas: quantitative relationships, program strategies, and analytical methods. The emerging trends in each of these areas are shown below and discussed in detail in the body of the paper.

Quantitative Relationships
- Program participation
- Medical care costs associated with health risks
- Wellness score associated with costs
- Changes in costs follow changes in risks
- Early cost savings
- Savings to costs ratios
- Risk reduction and risk avoidance
- Productivity costs associated with risks

Program Strategies
- The natural flow of a population
- Percent low risk
- Risks that cluster with others

Figure 1

Health Risk Appraisal Participation Rates



Participation rates are among 2433 continuously employed persons at the Progressive Corporation (1990 through 1999).

- Corporate wellness score

Analytical Methods

- Longitudinal data
- Fuzzy logic
- Data mining techniques

EMERGING TRENDS

Quantitative Relationships

"What works?" is a frequently asked question related to worksite health promotion programs. Determining what works does not seem to be a difficult question, yet in reality it is a very difficult task. Most worksite comparisons are between volunteer participants and nonparticipants, thus introducing a suspect self-selection bias. In addition to finding nonbiased groups, meaningful and valid outcome measures vary from program to program and from one population to another. The challenge remains to find consistent measures of meaningful participation and outcome measures. The following sections represent some of our recent and emerging findings in this broad area of quantitative relationships.

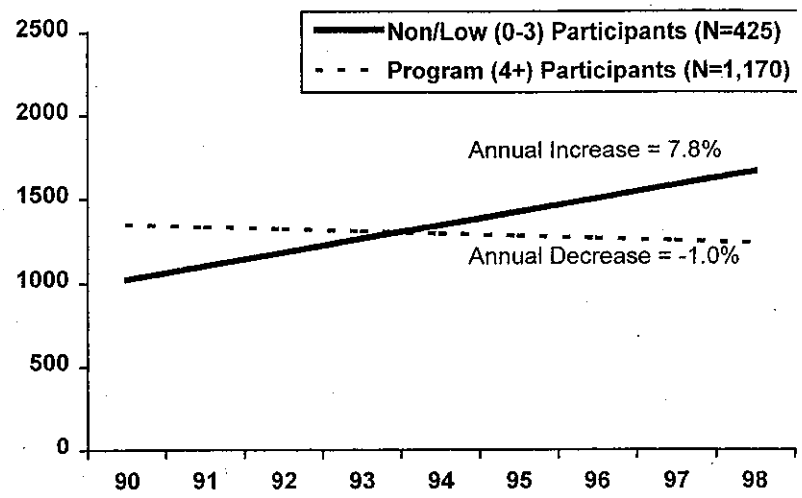
Program Participation. Most program managers are required to report program participation rates to senior management. The most accurate way to calculate participation is to capture each individual participation at the time of a program offering. Participation is measured often in 1-year windows, but the participation rate over several years is also very important. For example, health risk appraisals (HRA) are often used to raise health awareness and measure health status and changes in health status over time. An annual HRA participation rate of 20% to 30% is typically achieved. Among 2433 long-term employees at Progressive, we observed that over a 10-year period 80% of the employees participated at least once, with 60% participating at least twice and 40% at least three times (see Figure 1). These data indicate that given the opportunity the majority of employees eventually participate.[1] Employees at the other consortium companies have demonstrated the same participation pattern. When participation from the other program components is included, the overall cumulative participation rate often is increased by an additional 10% to 15%.

There are a variety of ways employees engage in a health promotion program that are nontrackable and thus are difficult to measure, such as reading a newsletter or calling an audio health library. In an early study at UAW-GM, the recorded cumulative participation was nearly 40% at the end of 3 years; however, a randomly administrated survey revealed that over 80% of the population had participated when the self-reported nontrackable components were included.[2] These nontrackable components may provide an important benefit and likely contribute to the overall cost-effectiveness of an established health promotion program.

Emerging research shows that the most important indicator of program success is participation in multiple programs. Getting individuals engaged over an extended period is important for long-term cost savings and indicates that those individuals who participate multiple times in a health promotion program have lower health care costs. The data in Figure 2 show medical care cost trends at Progressive and reveals that the individuals who participate in a program multiple times over a 9-year period have lower health care costs. In the example in Figure 2, the employees who were more involved in the health promotion program saved nearly $4.0 million over the 9 years shown (savings are the cumulative differences between the two regression lines). Similar data are available for the other partner companies.

Figure 2

Health Care Costs for Participants and Nonparticipants in the Health Promotion Program at Progressive Corporation



The 1595 persons evaluated were continuously employed and remained in the indemnity health plan for all 9 years (1990 through 1998).

Table 1

Health Risks and Behaviors

Health Risk Measure	High Risk Criteria
Alcohol	More than 14 drinks/wk
Blood pressure	Systolic >139 mm Hg or Diastolic >89 mm Hg
Body mass index	27.8 (men) 27.3 (women)
Cholesterol	>239 mg/dL
Existing medical problem	Heart problems, cancer, diabetes, stroke
HDL cholesterol	<35 mg/dL
Illness days	>5 days last year
Job satisfaction	Partly or not satisfied
Life satisfaction	Partly or not satisfied
Perception of health	Fair or poor
Physical activity	Less than one time/wk
Safety belt usage	Using safety belt less than 90% of time
Smoking	Current smoker
Stress	High
Use of drugs for relaxation	Few times a month or more
Overall risk levels	
Low risk	0–2 high risks
Medium risk	3–4 high risks
High risk	5 or more high risks

Medical Care Costs Associated with Health Risks. The literature indicates that high risk for any of the single risk factors is associated with higher medical costs.[3–7] The measurements we typically monitor are shown in Table 1. In addition, when individuals are grouped according to their overall health risk levels and age categories, those with the higher health risk levels are more expensive. In our studies we group overall health risk levels by zero to two (low risk), three to four (medium risk), and five or more (high risk). The data in Figure 3 show the typical distribution of medical costs by age and overall risk levels. The cost data include all charges for medical care, including Medicare for persons over age 65. It is clear that as age increases, medical costs increase. Others have shown similar results comparing age and medical costs.[8,9]

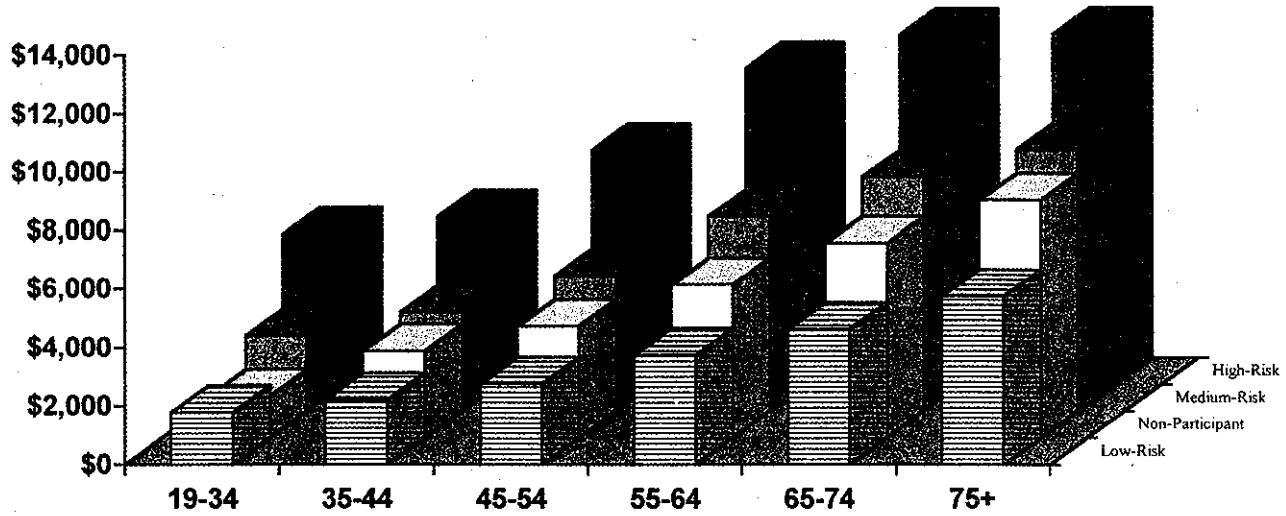
The data in Figure 3 also give rise to the concept that excess medical costs are associated with excess health risks. The lowest medical costs are associated with individuals in the low risk category. Excess costs are defined as the difference in medical care costs between the age-specific low risk group and the other respective risk groups times the respective number of people in each group. The percent of total corporate medical costs attributable to excess health risks is relatively consistent for each of our corporate partners, ranging from 21% to 31% with a mean close to 25%. Anderson et al.[10] used different methods to arrive at approximately the same result.

Wellness Score Associated With Costs. Nearly every commercial HRA calculates an overall wellness score, although the meaning of the score is not always obvious. The wellness score we created is calculated from our HRA and is used as a measure of current overall health status. The calculations for the wellness score includes three components: a function of the number of health risks, an interaction function related to the appraised age calculations from the Carter Center revisions, and a function related to the use of preventive services. The wellness score has a range of 40 to 100, a mean of 80, and an SD of 10.

Our emerging research indicates that the wellness score is directly related to health care costs (Figure 4). Although not illustrated, the wellness score is sensitive to

Figure 3

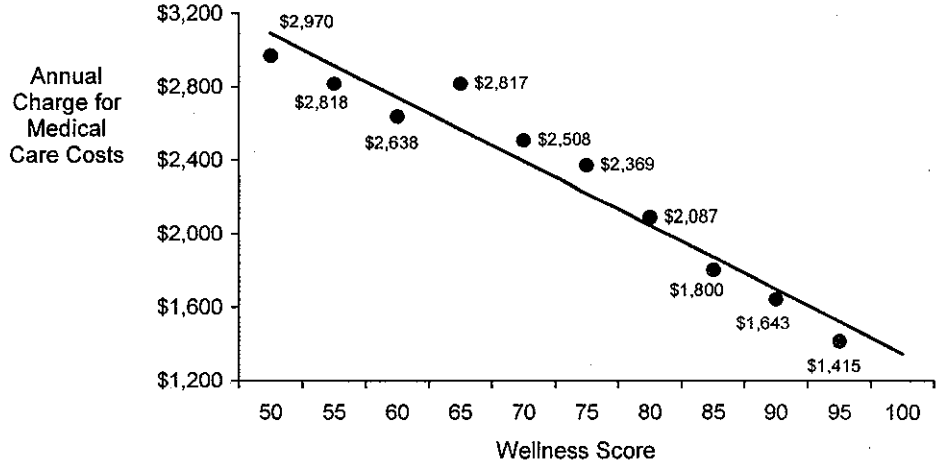
Annual Medical Charges for Different Ages and Health Risk Groups



The possible health risks are listed in Table 1 and the definitions are zero to two, three to four, and five or more for the low, medium, and high categories, respectively.

Figure 4

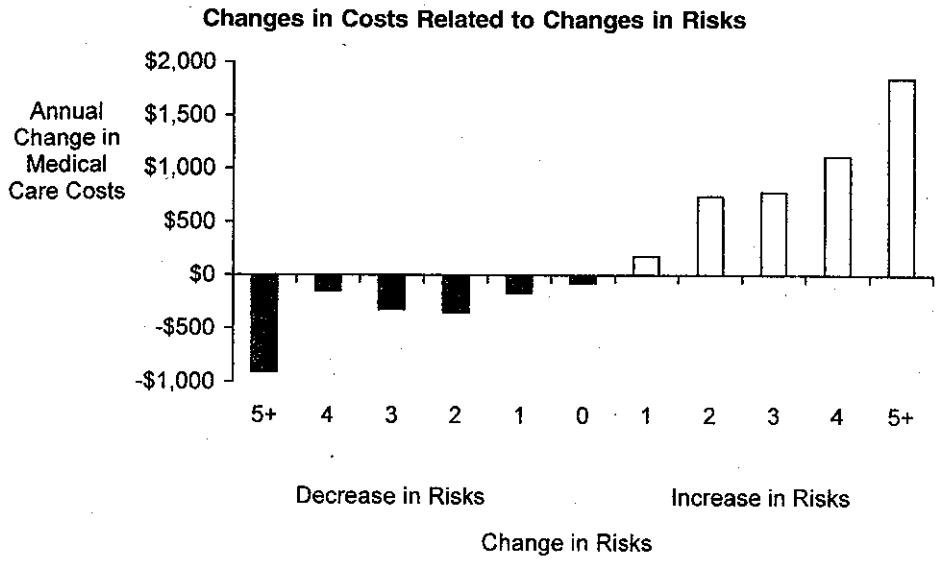
Wellness Scores and Charges for Medical Care Costs During the Same Year



age, gender, and the presence or absence of existing disease. Not only are higher wellness scores associated with lower health care costs, but changes in the wellness scores are associated with changes in health care costs. In a manufacturing population, a one-point change in the wellness score was associated with a $30 annual change in health care costs.

Changes in Costs Follow Changes in Risks. The relationships between health risks and health care costs are clear: individuals with high health risks have higher health care costs than low risk individuals.[7,11] Yet to be clarified is the link between changes in health costs associated with changes in health risks. Our experience shows that costs do follow risks. First demonstrated at Steelcase and now replicated in each of the other partner companies, we have discovered that as risks increase or decrease over time, the changes in costs follow in the same direction.[4] As a corollary to these findings, changes in risks were also observed in those individuals who changed health care cost categories (high-cost to and from low-cost categories). The outcome was as predicted: when individuals changed cost categories, their risks changed accordingly.[12] Both the cost-change and risk-change approaches used time-dated

Figure 5



risk changes that preceded or spanned the dates of the changes in costs.

Early Cost Savings. Another question often asked (especially by corporate financial services staffers) is, "When can we expect to see the benefits of these programs?" This is an important question but presents a technical challenge. To address this question, the outcome measure most likely needs to be partitioned into four time periods. First, there is the preprogram cost pattern. Second are the nontrackable components that could be making a difference, but most evaluation designs are not able to detect. Third is the latency period, which is the time between when the individual makes a change in lifestyle to when a change in their health care cost or productivity pattern occurs. Finally, there is the program period where the participants (eventually, multiple-time participants) are exhibiting the true effects of the health promotion program. In order to fully answer the financial question of "when," an evaluation program needs to be capable of partitioning the data for each individual. The necessary experimental design and capability is likely beyond the scope of most operating worksite programs. However, for the purpose of managing future expectations of management, it will be critically important for researchers to document these time periods for each of the different risks and behavior combinations. The research in this area is still emerging, and hopefully the expanding database and new analytical techniques will allow us to uncover these complex relationships.

When employees participate for extended periods of time, the low-cost programs are more likely to demonstrate early high savings to costs ratios. One of our consortium members observed a savings-to-cost ratio of over 3.5 within the third year for one of its low-cost programs. Even 3 years, however, is considered too long of an evaluation period for some corporations. The challenge is to find the right measures and early measures of success that indicate a program is on track to achieve the expected savings-to-costs ratios.

Savings to Costs Ratios. The technical challenge for economic studies is to include all of the program costs and savings, including health care, productivity, and other qualitative measures acceptable to the corporation. For one of our consortium members we found that program costs must remain below $30 per participant if savings-to-costs ratios above 3.0 are desired within the third year of the program. For this same consortium partner, the more intense programs, costing up to $200 per participant, generate additional savings but not enough to produce a 3.0 savings-to-cost ratio, at least not within the first 3 years. Our expectation is that as the program matures, the savings will continue to increase and exceed program costs by a factor of 3.0 within 5 years. The additional level of intensity is related primarily to high risk reduction programs, which show a moderate time lag between change in risks and changes in costs.

Risk Reduction and Risk Avoidance. The length of time necessary to observe the cost change in response to overall risk change is much shorter than we first hypothesized. Originally, we observed cost changes within 3 years of making a health change.[5] Pronk et al.[13] found that adverse health risk changes translated into significantly higher medical costs within 18 months. Our emerging data demonstrate that changes in medical costs associate with changes in health risks, even within 1 year in some cases. In Figure 5 we show the net risk change and the respective change in medical costs in a population of individuals

who completed an HRA in 2 successive years. The changes in medical costs follow in the same direction as the changes in health risks. An interesting observation is that the mean cost increase per risk increased is $350 per year and is greater than the mean cost decrease per risk decreased of $150 per year.

The above data fit with our other risk and cost-change data. However, the interesting question most often asked is, "Which risk factors are most likely to change, and what is the change in costs associated with that positive or negative risk change?" Even in our large database, controlling for age, gender, other risk factors, and other life situations presents a technical challenge to find a suitable population to answer the question.

Productivity Costs Associated With Risks. Loss of employee productivity is considered a major indirect cost for corporations. One frequently used surrogate measure of productivity is calculated from the number of days absent from work, including personal illness days, short- or long-term disability, or worker's compensation days. An early study at Steelcase indicated that the relationship of health risks to days absent was the same as the relationship of health risks to health care costs: excess disability days were associated with excess risks.[5]

The association between health status and worker's compensation lost workdays and associated injury claims show a strong relationship: high risk individuals are more likely to be high cost and—as was demonstrated with medical claims and days absent—when individuals changed risk status, workers' compensation costs followed in the same direction. Data from long-term employees at Xerox demonstrated that health risks are associated with total costs of worker's compensation claims and days lost. In addition, changes in worker's compensation followed changes in health risks.

Measuring productivity is more complex than counting absent and disability days. The complexity comes with the realization that not all absent employees are automatically nonproductive and not all employees present are automatically 100% productive. Isolating the components of absenteeism, disability, worker's compensation, and presenteeism (productivity while at work) has enabled us to more closely examine the impact of health risks on overall productivity. However, the definition of presenteeism varies from one set of jobs to another and is perhaps the most difficult of the productivity measures to estimate. At best, measures of presenteeism will be job-specific.

A study of call center operators included absent days due to occasional illness, disability days, and presenteeism as components of a productivity measure. The results showed that workers with higher health risks have more productivity loss, and that among the productivity components, presenteeism is the major contributor.[14] The "workers productivity index" may be a model calculation for future studies. Another important concept from the Bank One study is the realization that although all diseases result in decreased productivity, the typically low-cost diagnoses, such as asthma, allergies, mental health, irritable bowel syndrome, etc., are associated with high losses of productivity.[15] Although cancer and heart disease may result in higher medical care costs, these other diagnoses may be as important, or more important, in generating lost productivity costs. These results support the importance of disease management programs as a method of influencing medical costs, productivity, and, of course, overall health status and quality of life for individuals, families, and corporations.

Table 2

Risk and Cost Transitions Between Year 1 and Year 2 Among 5121 Health Risk Appraisal Participants*

	Year 2			
	Low (n)	Medium (n)	High (n)	Total (n)
Cost (Year 1)				
Low	1071	428	325	1824 (35.6%)
Medium	439	1062	384	1885 (36.8%)
High	298	464	650	1412 (27.6%)
	1808	1954	1359	5121 (100%)
	(35.6%)	(38.2%)	(26.5%)	
Risk (Year 1)				
Low	2603	423	67	3093 (60.4%)
Medium	546	574	214	1334 (26.0%)
High	87	250	357	694 (13.6%)
	3236	1247	638	5121 (100%)
	(63.2%)	(24.4%)	(12.5%)	

* Cost categories are annual charge cost of medical care of $0–$999 (low cost), $1000–$4999 (medium cost), and $5000 or more (high cost). Risk categories are low risk (0–2 risks), medium risk (3–4 risks), high risk (5 or more risks).

Program Strategies

The Natural Flow of a Population. By the early 1990s, we realized that health risks and medical care costs increased and decreased within a fixed worksite population independent of a health promotion program. We call this the natural flow of risks within a set population. This observation led to the formulation of the concept of low risk maintenance as an important contributor to net change in risk levels within a population. There is likely no perfect environment to observe a true natural flow of the population since the world is a dynamic place and almost no groups of individuals are totally free of interventions. Nevertheless, the transitions shown in Table 2 illustrate how a population distributes itself over 2 years of observation (the data are more complex when the model is extended to 3 and more years). If the "natural flow" of the population could be established early in a program, this flow of risks and costs could be the benchmark measure for success. The goal of the program should be to move the population into the low cost or low risk categories. Upper level managers should consider the portion of the population at low risk as the metric to measure the success of the health promotion program.

Percent Low Risk. Health promotion professionals are engaged in modifying high risks and maintaining low risks in individuals and populations. Our recommendation is that the program objective question become, "How does one create an environment to move people into and retain people in the low risk category?" Programs should be designed to keep people who are already low risk in the low risk category and move people who are at medium and high risk to lower risk status. The 5121 individuals represented in Table 2 illustrate the transitions people make in medical care costs and in health risks. For example, the data in Table 2 show that 2603 individuals were at low risk in year 1 and remained low risk in year 2; however, 423 individuals moved from low risk in year 1 to medium risk in year 2. If a program is to be successful, at the end of year 2 there should be more individuals at low risk. There are several ways to statistically test the model and a discussion of these methods is beyond the scope of this article. Our current analyses have shown that the most effective way to increase the portion of people in the low risk category is to prevent those at low risk from moving to medium or high risk. In other words, the most effective strategy is to keep the healthy people healthy.

The above discussion suggests that low risk maintenance programs are the key to success in maintaining lower health care costs. Although high risk individuals are often the targets of most health promotion programs, low risk individuals often receive little or no attention. It is clear that those low risk individuals are susceptible to increasing their risks without proper attention to help them maintain low risk status. Reducing the movement of low or medium risk individuals to high risk allows a program to successfully reduce the total number of high risk individuals within a few years.

Knowing the costs of a health promotion program and observing how individuals change over a 2 or more year period provides the information necessary to employ optimization procedures to determine how to invest future resources for the achievement of maximum flow of the population toward a low risk segment. Preliminary results from these investigations indicate that investment in the low and medium risk populations result in the maximum amount of change per dollar invested. These emerging results suggest that only when available program resources exceed $300 per person should health promotion programs target high risk individuals.

Risks that Cluster With Others. One of the major issues facing health promotion professionals is how to most effectively reach large populations with a diverse set of health profiles. Is it better to target the most prevalent risks in a population or to target those risks most highly associated with other risks? For example, overweight (body mass index [BMI] > 25) is nearly always the most prevalent risk factor within any worksite population. However, when other risks are examined in relation to overweight, it is observed that overweight has few consistent partners. That is, overweight individuals are often in the overall low risk level (one or two risks overall) and thus relatively low-cost. Although the long-term benefits of weight control are not necessarily questioned, the short-term economic benefits of focusing health promotion resources on overweight individuals in the overall low risk category are likely minimal.

The single risk most likely to travel with other risks is self-reported perception of health. It appears that individuals who have several other health risks tend to self-report their health as fair or poor. Although a relatively small percentage of the population is at high risk for perception of health, those who self-report fair or poor health are very likely to be at overall high risk status (four or more other risks) and will have high medical costs and low productivity.[16] Excellent returns would likely be achieved by providing these individuals extensive and relatively immediate attention.

These findings do not imply that risks not highly associated with other risks are unimportant. However, simply using the prevalence of risk within a population to guide the focus of health promotion programs may be insufficient for overall success of the health promotion program.

Corporate Wellness Score. Another question often asked by upper management is, "How are we doing compared with other companies?" The range, mean, and SD of individual wellness scores are important descriptors of the population, but these scores give only one dimension of the short-term success of a health promotion program. Given the previous discussion of the value of participation, we combined the wellness scores with a function of the program participation metrics to create a corporate wellness score. The resulting score can be used as a benchmark to compare companies, as well as a decision support tool to indicate where improvements can be made. The corporate score can be improved by improving the health status of the individuals (improved individual wellness scores) and by improved overall program participation rates. The manager has considerable and direct influence over participation rates through marketing and number of programs offered and indirect influence over the health status of the employee population by providing effective health promotion programming.

Analytical Methods

One of the research drivers at the University of Michigan Health Management Research Center is the recognition that a single data point at a single point in time does not indicate the rate or the direction of change. Although we (and others) have used these data points to make inferences, we understand the limitations to the science. Also, the effort to acquire that data point influences its future performance, similar to certain laws of quantum physics as described in the uncertainty principle by Nobel Prize–winning physicist Werner Heisenberg. These two concerns about the meaning of individual data points reinforced our need to perform longitudinal research to accumulate multiple data point measurements, thus ensuring the accuracy of the data points, establishing a trend

line, and adjusting for coincidence changes as the individual moves through his or her life.

Longitudinal Data. The ultimate power of our database comes from utilizing the longitudinal nature of data collected over long time spans. Previous work with these types of data typically involved logistic regression using only the data in each time period. However, repeated measurements taken from the same subject are correlated for obvious reasons, and the existence of within-cluster correlations violates the independence assumption of traditional methods, such as linear or logistic regression, and the detected associations may be biased or inaccurate. The introduction of generalized estimating equations (GEE) for correlated data has stimulated a great deal of interest.[17,18] Using GEE and controlling for age and gender, we found that psychological items, such as high stress, use of medications to relax, and job dissatisfaction are some of the health risk factors most associated with high medical claims costs longitudinally.

Fuzzy Logic. Currently, almost all the studies conducted on worksite health promotion programs use dichotomous cut points for health risks. The cut points can be easily accommodated with logistic regression where the independent variables are high or low risk and the dependent variable is the occurrence or nonoccurrence of disease or high- or low-cost health care cost status. These standard methods of partitioning precursors to disease into low, borderline, or high risk levels have been used in clinical programs and evaluation designs for at least the past 40 years. The well-defined longitudinal studies conducted in Framingham, Massachusetts, for example, have provided us with the cut points. In these studies the outcome measure is the occurrence or nonoccurrence of the disease. There is an important concept of "fuzziness," which when applied to this topic implies that all high, borderline, or low risk measures are not equal and could have different meanings in context with status of other factors, such as demographics, age, other risks, genetics, etc.[19]

When the outcome measure is changed to prospective health care costs, the equations need to be modified accordingly since the cost outcome is continuous and highly skewed. Our initial data show that when the independent variables (health risks) are treated with fuzzy cut points, rather than dichotomous, better results are obtained; that is, more of the value in the data is captured. For example, those values further away from the cut-point value may have increasingly more influential impact on the interaction with other risks and on their combined influence on the outcome measures. Continuing exploration of the data should lead to better models and more accuracy in the use of the risk factors to predict future use of the health care system.

Data Mining Techniques. Another influence on our work, from the field of physics and mathematics, has been the opportunity to apply some of the thoughts of Holland[20,21] to our database. If the data are perceived in this way, the more recent analytical tools now available in data mining can be applied.

In recent years, the power of machine learning and other artificial intelligence techniques to discover interesting patterns in raw data have become available (data mining). The research question that drives the need for new analytical techniques is, "When will an individual develop a disease (e.g., diabetes) or become high-cost?" This represents a major paradigm shift to time-oriented messages from simply identifying precursors to disease. If individuals complete repeated HRAs, it may be possible to solve the "when" question in the prospective diagnosis of diabetes or in predicting high-cost status. This emerging research uses a combination of advanced statistical methods and a sequential neural network approach.

By collecting and organizing the data appropriately, the concepts of the uncertainty principle, fuzziness, emergence, and data mining techniques can be combined to present unique insights into the data and perhaps solve some of the major, complex, and perplexing problems facing health clinicians. For example, the behavioral precursors to many of the major diseases facing Americans have been known for some time, yet many individuals continue to be overweight, lack exercise, and practice other behaviors that health experts and society, in general, consider unhealthy. The problem does not seem to be knowledge but motivation to change. It is obvious that new approaches are needed.

RESEARCH AGENDA

Our research agenda is dominated by the areas of emerging research, as documented in this paper, and by the decision support questions asked by our corporate consortium partners: "What works? What are the early indicators of success? What strategic interventions result in changes in costs? What is the time period before savings can be expected?" In addition, one of the more critical issues facing many health promotion programs is the issue of resource optimization; that is, given a limited amount of resources, "What is the optimal method of resource allocation for maximum results?" This optimization problem awaits sensitivity analyses of cost-effectiveness data for comprehensive and individual components of health promotion programs. In addition to the above areas of inquiry, we expect the issues around cumulative and repeated participation, the mix of personalized low risk maintenance and high risk reduction strategies, and the new opportunities related to advanced analytical methods to dominate our research activities for the remainder of the decade.

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