Relationship Between Modifiable Health Risks and Short-term Health Care Charges

Nicolaas P. Pronk, PhD
Michael J. Goodman, PhD
Patrick J. O’Connor, MD, MPH
Brian C. Martinson, PhD

Sedentary lifestyle, obesity, and tobacco use are strongly related to a variety of long-term adverse health outcomes, and over a lifetime, have significant costs to society. In formulating clinical policy and making resource allocation decisions, health care delivery organizations need to know the short-term relationship of modifiable health risks to health care charges. Managed care organizations (MCOs) attempt to maximize the value obtained from each health care dollar spent. Because adverse, modifiable health risks are detrimental to health and contribute to higher costs of health care, many MCOs may be interested in devoting resources to initiatives that favorably affect the health-related behaviors of their members. This is particularly true in light of recent reports documenting the efficacy of behavior change intervention strategies, lower health care charges with risk reduction, and a good return on investments in health-related behaviors. However, little financial data are available to guide resource allocation decisions, or to estimate the potential financial impact of programs that may modify health risks. Moreover, to our knowledge, no report has adequately controlled in the analysis for chronic conditions, which may confound the relationship of health risks to charges. In this study we analyze the short-term cost to health plans of modifiable health risks. These data provide an estimate of excess costs incurred by health plans that do nothing to influence modifiable health risks, and may assist health plans in deciding whether strategic investments to modify certain health risks in members is a wise use of scarce resources.

Context If physical inactivity, obesity, and smoking status prove to contribute significantly to increased health care charges within a short period of time, health plans and payers may wish to invest in strategies to modify these risk factors. However, few data are available to guide such resource allocation decisions.

Objective To examine the relationship of modifiable health risks to subsequent health care charges after controlling for age, race, sex, and chronic conditions.

Design, Setting, and Participants Cohort study of a stratified random sample of 5689 adults (75.5% of total sample of 7535) aged 40 years or older who were enrolled in a Minnesota health plan and completed a 60-item questionnaire.

Main Outcome Measure Resource use as measured by billed health care charges from July 1, 1995, to December 31, 1996, compared by health risk (physical activity, body mass index [BMI], and smoking status).

Results The mean annual per patient charge in the total study population was $3570 (median, $600), and 15% of patients had no charges during the study period. After adjustment for age, race, sex, and chronic disease status, physical activity (4.7% lower health care charges per active day per week), BMI (1.9% higher charges per BMI unit), current smoking status (18% higher charges), and history of tobacco use (25.8% higher charges) were prospectively related to health care charges over 18 months. Never-smokers with a BMI of 25 kg/m² and who participated in physical activity 3 days per week had mean annual health care charges that were approximately 49% lower than physically inactive smokers with a BMI of 27.5 kg/m².

Conclusions Our data suggest that adverse health risks translate into significantly higher health care charges within 18 months. Health plans or payers seeking to minimize health care charges may wish to consider strategic investments in interventions that effectively modify adverse health risks.

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guanide in 1994. Heart disease was assigned if the patients had 1 or more ICD-9 codes 412, 413.9, 429.2, or 428.0 in 1994. Hypertension was assigned if the patients had 1 or more ICD-9 codes 401, 401.1, or 401.9 in 1994. Dyslipidemia was assigned if the patients had an ICD-9 code of 272.4 in 1994. A more detailed description of the identification of patients with specific conditions and the sensitivity, specificity, and positive predictive value of this method has been published.6

From 158,415 patients with none of the 4 conditions, a random sample of 3000 members (1.89%) was selected. From 34,159 patients who had 1 chronic condition, a random sample of 2500 patients (7.3%) was selected. From 7571 patients who had 2 or more of the chronic conditions, a random sample of 2500 (33%) was selected. Hence, the total study population included a stratified random sample of 8000 individuals aged 40 years or older. In August 1995, a mailed survey was administered and 533 subjects who were unable to complete it due to death, disenrollment, or language problems were excluded. In addition, 159 proxy respondents were excluded from all analyses. Following postcard reminders at 7 days, a second mailing to nonrespondents at day 21, and telephone follow-up, data of a total of 5977 respondents (representing 79% of the total sample [5977/7535]) were available for analysis.

Data Definitions
The 60-question survey instrument included items on demographics, health status, use of preventive services, modifiable health risks, and readiness to change modifiable health risks. The core of the survey items was adapted from the Centers for Disease Control and Prevention’s Behavioral Risk Factor Surveillance System, which has reliability coefficients for behavioral risk factors above 0.70.7

Health care charges billed from July 1, 1995, to December 31, 1996, were used to measure relative resource use, and were gathered from the HealthPartners claims system. Each encounter in either MCO-owned or MCO-contracted clinics generated such a claim.

Important independent variables included age, race, sex, and chronic disease status. Prior research has shown that health care charges are associated with these variables before and after adjustment for functional health status and other factors.8,9 Age and sex were obtained from MCO administrative databases. Age was calculated in years from date of birth to the date of the initial survey. Chronic disease status was determined based on 1994 data.

Body mass index (BMI) was calculated as self-reported body weight in kilograms divided by self-reported height in meters squared, and was centered on its mean value. Physical activity was assessed via self-report and quantified in its mean value. Physical fitness was assessed using the questionnaire’s Behavioral Risk Factor Surveillance System, which has reliability coefficients for behavioral risk factors above 0.70.7

The statistical properties of each model were systematically assessed in nested fashion. First, the significance of each individual partial regression coefficient was assessed using a t test. This tested the hypothesis of whether an individual variable was related to variation in health care charges. Collinearity was assessed using variance inflation factors. In the semilogarithmic models, none of the variance inflation factors were greater than 1.20, suggesting that collinearity was not a significant problem in these models. Second, we analyzed residuals to be sure the distributional assumptions of the semilogarithmic linear regression were met. Third, overall goodness of fit was measured with the coefficient of determination, the adjusted $r^2$. Since the sample size was fixed for each model, the denominator used to calculate $r^2$ was fixed, allowing direct comparison of semilogarithmic models. Overall logistic model fit was assessed using the Hosmer-Lemeshow $\chi^2$ test.13 In the logistic regression, the performance of an individual coefficient was tested using a $\chi^2$ test.

The sampling structure of the survey required that we weight each observation based on its sampling probability to obtain population estimates. This was done in all multivariate analyses using standard methods.13 We further tested a generalized linear model assuming a gamma distribution and log link, which produced essentially identical results. Analyses were restricted to individuals with complete responses on all analysis variables. Results from the semilog model were retransformed using standard methods to present estimated effects in terms of mean charges in dollar units.14

**RESULTS**

Of the 5977 subjects (79%) who responded to the 1995 survey, 5689 had complete data on all study variables, and provide the basis of this report. Characteristics of survey respondents and nonrespondents are shown in Table 1.

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**Table 1. Comparison of Respondents and Nonrespondents**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Respondents (n = 5977)</th>
<th>Nonrespondents (n = 1558)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>47.2</td>
<td>55.1</td>
<td>.001</td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>59</td>
<td>54</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Staff clinic members</td>
<td>44.3</td>
<td>37.9</td>
<td>.001</td>
</tr>
</tbody>
</table>

*Values are percentages unless otherwise indicated. Values are not weighted.
†Presence of each of 4 chronic disease conditions determined by administrative records review of International Classification of Diseases, Ninth Revision, Clinical Modification codes and/or additional information related to pharmacotherapy. Conditions included diabetes mellitus, dyslipidemia, hypertension, and coronary heart disease.
Health care charges were highly skewed, with a small proportion of the population accounting for a large proportion of expense. The upper quintile of subjects accounted for 86% of total charges and the upper decile accounted for 71% of total charges. The median annual charge in our total study population was $600 (interquartile range, $151-$2080) compared with a mean (SD) of $3570 ($12823). Also, a significant proportion (15%) of study subjects had no medical encounters or charges during the 18-month study period.

The independent variable with the most missing data was BMI. Missing data precluded the calculation of BMI for 229 study subjects (198 users). Among those with health care charges, those with missing BMI had higher charges when measured on the log scale ($P < .001), were older ($P = .006), more likely to be men ($P < .001), and more likely to be hospitalized ($P = .005). The likelihood of health care charges did not differ between those with and without missing data for BMI.

Table 2 shows characteristics of study subjects with and without health care charges during the 18-month study period. Those with no health care charges were significantly younger, more likely to be men, more likely to be current smokers, and had significantly less chronic disease.

In models predicting probability of medical charges, each 10-year increase in age resulted in a 32% ($P < .001) increase in median charges. Current smokers had 18% higher median medical care charges than never-smokers and former smokers had medical care charges 25.8% higher than never-smokers did. The final column in Table 3 demonstrates the relationship of these and other risk factors with annualized median health care charges.

### Table 2. Characteristics of Study Subjects With and Without Health Care Charges*  

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Without Charges</th>
<th>With Charges</th>
<th>$P$</th>
<th>Effect on Median Charges, $\dollar$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y†</td>
<td>55.59</td>
<td>61.00</td>
<td>&lt;.001</td>
<td>22.35</td>
</tr>
<tr>
<td>Body mass index, kg/m²†</td>
<td>27.16</td>
<td>27.46</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Physical activity‡</td>
<td>2.68</td>
<td>2.65</td>
<td>.73</td>
<td></td>
</tr>
<tr>
<td>Dyslipidemia‡</td>
<td>29.87</td>
<td>27.11</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus‡</td>
<td>13.58</td>
<td>19.57</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Hypertension‡</td>
<td>20.16</td>
<td>41.59</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Heart disease‡</td>
<td>13.23</td>
<td>21.61</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>57.38</td>
<td>46.47</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>94.03</td>
<td>94.56</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>19.79</td>
<td>13.42</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Former smoker</td>
<td>41.33</td>
<td>43.85</td>
<td>.17</td>
<td></td>
</tr>
</tbody>
</table>

*Values are based on data from 5689 subjects except for fitness in which data from only 4030 subjects was used. Values are percentages unless otherwise indicated. Results are not weighted.
†Effects assessed by combining the odds of charges and effects on charges.
‡Predicted oxygen consumption per unit time expressed as milliter per kilogram per minute. Data based on self-reported physical activity behavior and demographic characteristics and calculated using the prediction equation by Ainsworth et al.11
| Presence of each chronic disease condition determined by administrative records review of International Classification of Diseases, Ninth Revision, Clinical Modification codes and/or additional information related to pharmacotherapy.

### Table 3. Combined Multivariate Results From Models Predicting Presence and Level of Health Care Charges*  

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Combined Effect on Charges, %†</th>
<th>Clinical Interpretation</th>
<th>Annual Effect on Median Charges, $\dollar$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3.7</td>
<td>An additional year of age yields a 3.7% increase in median charges</td>
<td>22.35</td>
</tr>
<tr>
<td>Male</td>
<td>−39.0</td>
<td>Males have median charges 39% lower than females</td>
<td>−234.00</td>
</tr>
<tr>
<td>White</td>
<td>−27.2</td>
<td>Whites have 27% lower median charges than nonwhites</td>
<td>−163.23</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>137.1</td>
<td>Members with diabetes have 137% higher charges than non diabetic members</td>
<td>822.81</td>
</tr>
<tr>
<td>Heart disease</td>
<td>150.3</td>
<td>Median charges are 150% higher for members with heart disease</td>
<td>901.60</td>
</tr>
<tr>
<td>Body mass index</td>
<td>1.9</td>
<td>A 1-unit increase in body mass index yields a 1.9% increase in median charges</td>
<td>11.26</td>
</tr>
<tr>
<td>Physical activity§</td>
<td>−4.7</td>
<td>An additional day of physical activity (above zero) yields a 4.7% reduction in median charges</td>
<td>−27.99</td>
</tr>
<tr>
<td>Current smoker</td>
<td>18.0</td>
<td>Current smokers have 18% higher median charges than nonsmokers</td>
<td>107.81</td>
</tr>
<tr>
<td>Former smoker</td>
<td>25.8</td>
<td>Former smokers have 26% higher median charges than never-smokers</td>
<td>154.86</td>
</tr>
</tbody>
</table>

*Results derived from combining the results from a multivariate logistic regression predicting presence of charges and a multivariate least-squares regression predicting log of charges, among those having charges. For the logistic model, effects were significant for age and male sex at $P < .01$. All other effects were not statistically significant. All effects in the least-squares regression were significant at $P < .01$. Direct results of these 2 models are available from the corresponding author. Effects assessed by combining the odds of charges and effects on charges.
†Assessed among members with and without charges. Median annual charges for the total group were $600.00.
‡Values are based on subjects’ activity in the days during the prior week.
§Predicted oxygen consumption per unit time expressed as milliter per kilogram per minute. Data based on self-reported physical activity behavior and demographic characteristics and calculated using the prediction equation by Ainsworth et al.11

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The changes in mean dollars implied by our models vary depending on the specific characteristics of individuals. Table 4 presents descriptive estimates of mean annual charges for hypothetical patients with high-risk vs low-risk profiles of modifiable health risks. These estimates are based on least-squares regression results, estimated only for subjects with nonzero charges. The high-risk profile was associated with a fixed-percentage increase of 49% mean annual charges higher than the low-risk profile. However, across the range of individuals with characteristics as presented in column 1, the absolute increase in mean charges ranged from approximately $1500 to more than $2500.

**TABLE 4. Bias-Corrected Estimates of Mean Annual Health Care Charges for Hypothetical Members With Nonzero Charges and Selected Profiles of Modifiable Health Risks**

<table>
<thead>
<tr>
<th>Subject Profile</th>
<th>Low-Risk Profile</th>
<th>High-Risk Profile</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>White woman</td>
<td>5903.95</td>
<td>9399.51</td>
<td>1945.56</td>
</tr>
<tr>
<td>White man</td>
<td>3122.65</td>
<td>4643.78</td>
<td>1521.13</td>
</tr>
<tr>
<td>Nonwhite woman</td>
<td>5266.32</td>
<td>7831.69</td>
<td>2565.37</td>
</tr>
<tr>
<td>Nonwhite man</td>
<td>4117.45</td>
<td>6123.17</td>
<td>2005.72</td>
</tr>
</tbody>
</table>

*All values are in US dollars. To correct estimates for bias resulting from retransformation from log dollars to dollars, the Duan14 smearing method was used. Estimates may reflect selection bias since they are based on a regression predicting log charges only among those having charges. Overall mean charges for those with charges was $4201.10.
†Age 60 years without congenital heart disease or diabetes mellitus.
‡Body mass index of 25 kg/m², never-smoker, participate in physical activity 3 days per week.
§Body mass index of 27.5 kg/m², current smoker, does not participate in physical activity.

While health-risk reduction is not a panacea for controlling health care costs, we believe that payers often undervalue its merits. Other reports document better clinical outcomes,17,18 and suggest lower subsequent costs,3,5,19,20 when modifiable health risks are improved. While some behavior change interventions are expensive, others are less costly, yet effective, and the return on investment may be favorable.21 Moreover, we have shown in previous work that readiness to change and willingness to participate in health improvement activities tend to be greatest in those at highest risk of poor outcomes.21,22

Further, this report documents a short lag time between the measurement of modifiable health risks and their impact on health care charges. This short lag time, only 18 months in this study, is plausibly from the biological point of view for physical activity and weight management.21,24 Moreover, while disenrollment rates may vary widely from one health plan to another,25,26 there is evidence in recent reports that older, sicker health plan members have lower rates of disenrollment than do younger, healthier members.27 Because the percentage change in health care charges is relatively constant across age groups, potential short-term savings may be highest in older, sicker members.

However, an additional problem relates to the notion that when behavior change interventions target only high-risk individuals, the observed shift from high to average risk is offset by individuals who move from average risk to high-risk status. To achieve lasting health benefit in defined populations, health plans and their community partners would be well-advised to address the needs of both average-risk and high-risk members, through intervention at both the individual and community levels.28

The relationship of smoking status to health care charges is complex. The higher charges among former smokers than current smokers are likely to reflect the occurrence of health problems that caused smokers to stop, for example, after a myocardial infarction.29 Our data corroborate previously published reports29 suggesting...
that primary prevention of smoking is an important strategy to improve population health and reduce charges.

This study has several limitations. Our data were limited to a large group of insured patients enrolled in a single health plan. The magnitude of these patients’ health care charges may differ from those with indemnity insurance, although the expected impact would be to make our estimates of charges conservative. Further, the relatively high educational level and demographic homogeneity of the MCO membership studied here limit the generalizability of our results to other groups, especially minority populations. While we did not include data on alcohol intake and nutrition in our analyses, both appear to be related in a complex fashion to health care charges.13 Our measurements of BMI and physical activity are based on self-report, but reporting bias would likely make our estimates of the effect of modifiable risks on charges conservative. These limitations should be balanced against the strengths of this study. The population we studied was large enough to ensure sufficient power in the analysis, and is comparable with populations enrolled in many other health plans. The data on health care charges, while not perfect, are derived from a single source with uniform databases and charges, and are virtually complete.6 The ability to control for important comorbidities and the use of appropriate analytic models are also strengths of this study. Also, few other studies have analyzed the relationship of modifiable health risks to direct health care charges using empiric, individual level data and appropriate multivariate statistical models.31

Our results suggest that adverse, modifiable health risks contribute substantially to health care charges. While the reversibility of these charges with changes in health risks remains uncertain, a recent report1 suggests that reduction in risks may lead to reduced charges, and other work3 indicates a high return on investment to payers with interventions that reduce health risks. Other data12,31 indicate that risk reduction leads to reduced mortality, which provides a plausible biological pathway between risks and charges. Health plans and self-insured employers seeking to maximize health return on each dollar spent for medical care may wish to consider strategic investments in interventions that effectively improve modifiable health risks. From a behavioral perspective, primary prevention of smoking and increased physical activity appear to have substantial potential to reduce health care charges.

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