### **Figure 1Timeline**



### **Table 1**

### **Description of the Study Sample**

|  |  |
| --- | --- |
| **Variable** | **Value** |
| Employees, n | 135,219 |
| Employers, n | 11 |
| Employee characteristics |
| Female, % | 54.8 |
| Age, years, % |  |
| 18–25 | 3.6 |
| 26–35 | 26.2 |
| 36–45 | 26.9 |
| 46–64 | 43.3 |
| Salaried, % | 42.0 |
| Charlson Comorbidity Index | 0.284 |
| Psychiatric Diagnostic Groupings | 0.224 |
| Region, % |
| Northeast | 23.6 |
| North central | 20.9 |
| South | 42.6 |
| West | 12.9 |
| Health plan type, % |
| Health maintenance organization  | 1.8 |
| Preferred provider organization  | 83.8 |
| High deductible  | 14.4 |
| Industry type, % |
| Information and finance | 14.7 |
| Manufacturing | 44.4 |
| Retail | 40.8 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database.

### **Table 2Prevalence and Medical Expenditures Associated With Health Risk Factors**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Prevalence, % at High Risk** | **Annual Health Care Spending** |
| Risk factor (n=135219)  |  |  |
| High blood pressure | 9.9 |  |
| High cholesterol | 5.9 |  |
| High blood glucose | 7.6 |  |
| High BMI | 30.8 |  |
| Poor diet | 86.9 |  |
| Tobacco use | 6.8 |  |
| High alcohol consumption | 1.7 |  |
| High stress | 18.4 |  |
| Depression | 11.8 |  |
| Lack of adequate exercise | 23.6 |  |
| Total spending  |  |  |
| Mean, $ |  | 4182 |
| Std. Dev., $ |  | 8040 |
| % with $0 spending |  | 4.85 |
| Inpatient spending |  |  |
| Mean, $ |  | 854 |
| SD, $ |  | 5665 |
| % with $0 spending |  | 96.2 |
| Outpatient spending |  |  |
| Mean, $ |  | 1995 |
| SD, $ |  | 3046 |
| % with $0 OP spending |  | 7.8 |
| Emergency department spending |  |  |
| Mean, $ |  | 353 |
| SD, $ |  | 1251 |
| % with $0 spending |  | 86.8 |
| Preventive care spending |  |  |
| Mean, $ |  | 170 |
| SD, $ |  | 264 |
| % with $0 spending |  | 28.3 |
| Outpatient pharmaceutical spending |  |  |
| Mean, $ |  | 810 |
| SD, $ |  | 1566 |
| % with $0 spending |  | 16.4 |

Sourcewas the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates Body Mass Index. Health care expenditures are in 2016 dollars.

### **Table 3****Unadjusted Medical Spending Differentials Between High- and Low-Risk Employees, Overall and by Medical Service**

|  |  |  |
| --- | --- | --- |
| **Medical Service Category** | **Health Risk** | **Spending by Risk Factor, $** |
| **High Blood Pressure** | **High Cholesterol** | **High Glucose** | **High BMI** | **Poor Diet** | **Tobacco Use** | **High Alcohol Use** | **High Stress** | **Depression** | **Low Exercise** |
| Total | Lower | 4150 | 4169 | 4021 | 3738 | 4269 | 4180 | 4184 | 4027 | 4010 | 4046 |
| High | 4475 | 4395 | 6044 | 5178 | 4169 | 4208 | 4107 | 4873 | 5357 | 4969 |
| Dif. | 325 | 226 | 2023 | 1440 | –100 | 28 | –76 | 846 | 1347 | 923 |
| Inpatient | Lower | 833 | 837 | 807 | 704 | 675 | 852 | 854 | 812 | 817 | 833 |
| High | 1040 | 1129 | 1392 | 1189 | 881 | 885 | 831 | 1041 | 1080 | 1247 |
| Dif. | 207 | 292 | 585 | 485 | 206 | 33 | –23 | 229 | 264 | 414 |
| Outpatient | Lower | 1995 | 1996 | 1957 | 1850 | 2246 | 2004 | 1995 | 1937 | 1919 | 1923 |
| High | 1994 | 1981 | 2411 | 2321 | 1957 | 1868 | 2001 | 2252 | 2539 | 2183 |
| Dif. | -1 | –15 | 455 | 471 | –288 | –136 | 6 | 315 | 620 | 259 |
| Emergency department | Lower | 348 | 353 | 344 | 300 | 303 | 345 | 354 | 327 | 334 | 340 |
| High | 403 | 359 | 478 | 473 | 361 | 471 | 315 | 471 | 508 | 437 |
| Dif. | 55 | 6 | 134 | 172 | 58 | 126 | –39 | 144 | 174 | 97 |
| Retail prescriptions | Lower | 802 | 813 | 744 | 712 | 849 | 807 | 810 | 779 | 770 | 778 |
| High | 883 | 757 | 1595 | 1029 | 804 | 842 | 781 | 945 | 1057 | 936 |
| Dif. | 81 | –56 | 851 | 318 | –45 | 35 | –29 | 166 | 287 | 157 |
| Preventive | Lower | 172 | 170 | 170 | 172 | 197 | 172 | 170 | 172 | 169 | 171 |
| High | 155 | 169 | 168 | 166 | 166 | 142 | 179 | 165 | 172 | 167 |
| Dif. | -17 | –1 | –2 | –6 | –31 | –31 | 9 | –7 | 3 | –4 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates Body Mass Index; Dif. Indicates difference.

### **Table 4Adjusted Medical Spending Differentials Between High and Low Risk Employees Overall and by Medical Service**

**Spending by Risk Factor, $**

|  |  |
| --- | --- |
| **Medical Service Category** | **Health Risk** |
| **Blood Pressure** | **Cholesterol** | **Glucose** | **BMI** | **Diet** | **Tobacco Use** | **Alcohol** | **Stress** | **Depression** | **Exercise** |
| All health | Lower | 4215  | 4206  | 4058  | 3873  | 4371  | 4211  | 4205  | 4078  | 4101  | 4176  |
| High | 4079  | 4112  | 5752  | 4873  | 4175  | 4056  | 3956  | 4720  | 4717  | 4597  |
| Dif. | -136 | -94 | 1694\*\* | 1000\*\* | -195 | -155 | -248 | 642\*\* | 616\*\* | 421\*\* |
| Inpatient | Lower | 853  | 844  | 823  | 750  | 853  | 863  | 858  | 836  | 844  | 877  |
| High | 908  | 1076  | 1213  | 1072  | 859  | 803  | 885  | 950  | 889  | 1115  |
| Dif. | 56 | 232\*\* | 390\*\* | 322\*\* | 6 | -60 | 27 | 114\*\* | 45 | 238\*\* |
| Outpatient | Lower | 2018  | 2012  | 1969  | 1899  | 2135  | 2015  | 2007  | 1954  | 1959  | 1973  |
| High | 1885  | 1884  | 2374  | 2229  | 1983  | 1862  | 1853  | 2224  | 2292  | 2059  |
| Dif. | -133\*\* | -128\*\* | 405\*\* | 329\*\* | -151\*\* | -153\*\* | -154\*\* | 270\*\* | 333\*\* | 86\*\* |
| Emergency department | Lower | 349  | 352  | 346  | 314  | 357  | 346  | 353  | 336  | 340  | 357  |
| High | 374  | 348  | 428  | 426  | 351  | 424  | 286  | 411  | 433  | 380  |
| Dif. | 24\* | -4 | 82\*\* | 112\*\* | -6 | 78\*\* | -67\* | 75\*\* | 93\*\* | 23\* |
| Retail prescriptions | Lower | 816  | 815  | 741  | 734  | 821  | 807  | 808  | 784  | 784  | 796  |
| High | 742  | 688  | 1578  | 953  | 805  | 806  | 753  | 910  | 916  | 860  |
| Dif. | -74\*\* | -128\*\* | 837\*\* | 219\*\* | -16 | -1 | -55 | 125\*\* | 133\*\* | 63\*\* |
| Preventive | Lower | 173  | 172  | 171  | 173  | 174  | 173  | 171  | 170  | 170  | 171  |
| High | 153  | 157  | 171  | 166  | 170  | 141  | 172  | 175  | 170  | 166  |
| Dif. | -20\*\* | -14\*\* | 1 | -8\*\* | -3 | -32\*\* | 1 | 5\* | 0 | -5\* |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates Body Mass Index; Dif. Indicates difference.

\* Statistical significance of the adjusted difference at p < .05.

\*\* Statistical significance of the adjusted difference at p < .001.

### **Table 5Average Adjusted and Unadjusted Medical Expenditures by Risk Level**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Risk Measure and Level** | **Unadjusted Mean, $** | **Adjusted Mean, $** | **Unadjusted Difference, %** | **Adjusted Difference, %** |
| Blood glucose |  |  |  |  |
| High | 6044  | 5752  | 50.3 | 41.8\* |
| Lower | 4021  | 4058  | –^ | –^ |
| BMI |  |  |  |  |
| High | 5178  | 4873  | 38.5 | 25.8\* |
| Lower | 3738  | 3873  | –^ | –^ |
| Stress |  |  |  |  |
| High | 4873  | 4720  | 21.0 | 15.7\* |
| Lower | 4027  | 4078  | –^ | –^ |
| Depression |  |  |  |  |
| High | 5357  | 4717  | 33.6 | 15.0\* |
| Lower | 4010  | 4101  | –^ | –^ |
| Poor exercise |  |  |  |  |
| High | 4969  | 4597  | 22.8 | 10.1\* |
| Lower | 4046  | 4176  | –^ | –^ |
| Total cholesterol |  |  |  |  |
| High | 4395  | 4112  | 5.4 | -2.2 |
| Lower | 4169  | 4206  | –^ | –^ |
| Blood pressure |  |  |  |  |
| High | 4475 | 4079  | 7.8 | -3.2 |
| Lower | 4150  | 4215  | –^ | –^ |
| Tobacco use |  |  |  |  |
| High | 4208  | 4056  | 0.7 | -3.7 |
| Lower | 4180  | 4211  | –^ | –^ |
| Poor diet |  |  |  |  |
| High | 4169  | 4175  | -2.3 | -4.5 |
| Lower | 4269  | 4371  | –^ | –^ |
| Alcohol consumption |  |  |  |
| High |  4107  |  3956  | -1.8 | -5.9 |
| Lower |  4184  |  4205  | –^ | –^ |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates Body Mass Index.

^Reference category.

\* Indicates statistical significance of the adjusted difference at P < .001 level.

### **Table 6Estimated Effect of Health Risks on Annual per Capita Medical Expenditures**

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk Factor** | **Estimated Annual Effect per High-Risk Person, $** | **Prevalence:** **People With** **High Risk, n** | **High-risk group annual effect** |
| **Cost, $** | **Total Annual Expenditures, %** | **Cost per Capita, $** |
| BMI | 1000 | 41683 | 41700340 | 7.4 | 308.4 |
| Glucose | 1694 | 10257 | 17380137 | 3.1 | 128.5 |
| Stress | 642 | 24838 | 15940519 | 2.8 | 117.9 |
| Exercise | 421 | 26287 | 11074477 | 2.0 | 81.9 |
| Depression | 616 | 15606 | 9612803 | 1.7 | 71.1 |
| Alcohol Consumption | -248 | 2297 | -570388 | -0.1 | -4.2 |
| Cholesterol | -94 | 7442 | -699940 | -0.1 | -5.2 |
| Tobacco Use | -155 | 9247 | -1431378 | -0.3 | -10.6 |
| Blood Pressure | -136 | 13321 | -1812421 | -0.3 | -13.4 |
| Diet | -195 | 117538 | -22975546 | -4.1 | -169.9 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates Body Mass Index.

### **Exhibit A1Regression Model Output Corresponding to Table 4 Adjusted Findings, Annual Total Health Care, Inpatient, and Outpatient Spending (n=135219)**

|  |  |  |  |
| --- | --- | --- | --- |
| Independent Variable | Annual Total Health Care Spending | Annual Inpatient Spending | Annual Outpatient Spending |
| Coefficient | SE | P | Coefficient | SE | P | Coefficient | SE | P |
| Intercept | 8.10 | 0.04 | <.0001 | 6.25 | 0.08 | <.0001 | 7.33 | 0.02 | <.0001 |
| Risk for blood pressure | -0.03 | 0.03 | 0.24 | 0.06 | 0.05 | 0.19 | -0.07 | 0.01 | <.0001 |
| Risk for cholesterol | -0.02 | 0.04 | 0.53 | 0.24 | 0.06 | <.0001 | -0.07 | 0.02 | <.0001 |
| Risk for blood glucose | 0.35 | 0.03 | <.0001 | 0.39 | 0.04 | <.0001 | 0.19 | 0.01 | <.0001 |
| Risk for BMI | 0.23 | 0.02 | <.0001 | 0.36 | 0.03 | <.0001 | 0.16 | 0.01 | <.0001 |
| Risk for diet | -0.05 | 0.03 | 0.11 | 0.01 | 0.06 | 0.91 | -0.07 | 0.01 | <.0001 |
| Risk for tobacco use | -0.04 | 0.04 | 0.29 | -0.07 | 0.06 | 0.26 | -0.08 | 0.02 | <.0001 |
| Risk for alcohol consumption | -0.06 | 0.07 | 0.38 | 0.03 | 0.13 | 0.80 | -0.08 | 0.03 | 0.01 |
| Risk for stress | 0.15 | 0.02 | <.0001 | 0.13 | 0.04 | 0.00 | 0.13 | 0.01 | <.0001 |
| Risk for depression | 0.14 | 0.02 | <.0001 | 0.05 | 0.05 | 0.27 | 0.16 | 0.01 | <.0001 |
| Risk for adequate exercise | 0.10 | 0.02 | <.0001 | 0.24 | 0.04 | <.0001 | 0.04 | 0.01 | <.0001 |
| Age: 18–25 | -0.46 | 0.07 | <.0001 | -0.32 | 0.12 | 0.01 | -0.57 | 0.03 | <.0001 |
| Age: 26–35 | -0.30 | 0.02 | <.0001 | 0.04 | 0.04 | 0.35 | -0.40 | 0.01 | <.0001 |
| Age: 36–45 | -0.25 | 0.02 | <.0001 | -0.32 | 0.05 | <.0001 | -0.20 | 0.01 | <.0001 |
| Female | 0.29 | 0.02 | <.0001 | 0.45 | 0.04 | <.0001 | 0.34 | 0.01 | <.0001 |
| Salaried | 0.04 | 0.02 | 0.03 | -0.03 | 0.04 | 0.46 | 0.10 | 0.01 | <.0001 |
| Health plan: HMO | -0.03 | 0.08 | 0.70 | -0.07 | 0.15 | 0.65 | 0.00 | 0.03 | 0.98 |
| Health plan: high deductible | -0.39 | 0.04 | <.0001 | -0.44 | 0.08 | <.0001 | -0.33 | 0.01 | <.0001 |
| Location: northeast | 0.00 | 0.02 | 0.84 | 0.06 | 0.04 | 0.18 | 0.10 | 0.01 | <.0001 |
| Location: north central | -0.01 | 0.03 | 0.60 | 0.04 | 0.05 | 0.44 | 0.06 | 0.01 | <.0001 |
| Location: west | -0.04 | 0.03 | 0.15 | 0.07 | 0.05 | 0.13 | 0.03 | 0.01 | 0.02 |
| Location: unknown | -0.90 | 3.22 | 0.78 | -14.68 | 0.00 | <.0001 | -33.68 | 0.00 | <.0001 |
| Employer 1 | 0.37 | 0.07 | <.0001 | 0.63 | 0.11 | <.0001 | 0.23 | 0.03 | <.0001 |
| Employer 2 | 0.24 | 0.02 | <.0001 | 0.19 | 0.04 | <.0001 | 0.25 | 0.01 | <.0001 |
| Employer 3 | 0.00 | 0.13 | 0.98 | -0.04 | 0.24 | 0.86 | 0.08 | 0.06 | 0.15 |
| Employer 4 | 0.62 | 0.10 | <.0001 | 0.93 | 0.15 | <.0001 | 0.58 | 0.04 | <.0001 |
| Employer 5 | 0.11 | 0.06 | 0.08 | -0.96 | 0.32 | 0.00 | 0.24 | 0.02 | <.0001 |
| Employer 6 | 0.03 | 0.05 | 0.59 | -0.52 | 0.15 | 0.00 | 0.19 | 0.02 | <.0001 |
| Employer 7 | 0.14 | 0.09 | 0.13 | -0.12 | 0.24 | 0.61 | 0.24 | 0.04 | <.0001 |
| Employer 8 | 0.20 | 0.09 | 0.03 | 0.08 | 0.19 | 0.68 | 0.30 | 0.04 | <.0001 |
| Employer 9 | 0.19 | 0.06 | 0.00 | -0.79 | 0.28 | 0.00 | 0.29 | 0.02 | <.0001 |
| Employer 10 | 0.01 | 0.05 | 0.89 | -0.17 | 0.11 | 0.12 | 0.12 | 0.02 | <.0001 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates body mass index; HMO indicates health maintenance organization.

### **Exhibit A2Regression Model Output Corresponding to Table 4 Adjusted Findings, Annual Emergency Department, Retail Prescription Drug, and Preventative Spending (n=135,219)**

|  |  |  |  |
| --- | --- | --- | --- |
| Independent Variable | Emergency Department Spending | Prescription Drug Spending | Preventative Spending |
| Coefficient | SE | P | Coefficient | SE | P | Coefficient | SE | P |
| Intercept | 5.57 | 0.04 | <.0001 | 6.57 | 0.02 | <.0001 | 5.10 | 0.02 | <.0001 |
| Risk for blood pressure | 0.07 | 0.03 | 0.01 | -0.09 | 0.01 | <.0001 | -0.12 | 0.01 | <.0001 |
| Risk for cholesterol | -0.01 | 0.04 | 0.77 | -0.17 | 0.02 | <.0001 | -0.09 | 0.02 | <.0001 |
| Risk for blood glucose | 0.21 | 0.03 | <.0001 | 0.76 | 0.01 | <.0001 | 0.00 | 0.02 | 0.82 |
| Risk for BMI | 0.30 | 0.02 | <.0001 | 0.26 | 0.01 | <.0001 | -0.05 | 0.01 | <.0001 |
| Risk for diet | -0.02 | 0.03 | 0.60 | -0.02 | 0.01 | 0.16 | -0.02 | 0.01 | 0.08 |
| Risk for tobacco use | 0.20 | 0.03 | <.0001 | 0.00 | 0.02 | 0.94 | -0.20 | 0.02 | <.0001 |
| Risk for alcohol consumption | -0.21 | 0.08 | 0.01 | -0.07 | 0.04 | 0.06 | 0.00 | 0.03 | 0.87 |
| Risk for stress | 0.20 | 0.02 | <.0001 | 0.15 | 0.01 | <.0001 | 0.03 | 0.01 | 0.01 |
| Risk for depression | 0.24 | 0.02 | <.0001 | 0.16 | 0.01 | <.0001 | 0.00 | 0.01 | 0.89 |
| Risk for adequate exercise | 0.06 | 0.02 | 0.00 | 0.08 | 0.01 | <.0001 | -0.03 | 0.01 | 0.01 |
| Age: 18–25 | 0.30 | 0.04 | <.0001 | -0.72 | 0.05 | <.0001 | -0.70 | 0.03 | <.0001 |
| Age: 26–35 | 0.11 | 0.02 | <.0001 | -0.57 | 0.02 | <.0001 | -0.66 | 0.01 | <.0001 |
| Age: 36–45 | 0.08 | 0.02 | 0.00 | -0.35 | 0.01 | <.0001 | -0.47 | 0.01 | <.0001 |
| Female | 0.42 | 0.02 | <.0001 | 0.03 | 0.01 | 0.01 | 0.36 | 0.01 | <.0001 |
| Salaried | -0.23 | 0.02 | <.0001 | 0.07 | 0.01 | <.0001 | 0.16 | 0.01 | <.0001 |
| Health plan: HMO | 0.08 | 0.09 | 0.37 | -0.09 | 0.04 | 0.01 | -0.04 | 0.03 | 0.22 |
| Health plan: high deductible | -0.39 | 0.05 | <.0001 | -0.60 | 0.02 | <.0001 | -0.03 | 0.01 | 0.01 |
| Location: northeast | -0.39 | 0.03 | <.0001 | -0.18 | 0.01 | <.0001 | 0.09 | 0.01 | <.0001 |
| Location: north central | -0.24 | 0.03 | <.0001 | -0.16 | 0.01 | <.0001 | 0.05 | 0.01 | <.0001 |
| Location: west | -0.22 | 0.03 | <.0001 | -0.21 | 0.02 | <.0001 | -0.16 | 0.01 | <.0001 |
| Location: unknown | -11.34 | 0.00 | <.0001 | 0.36 | 0.29 | 0.22 | -12.56 | 0.00 | <.0001 |
| Employer 1 | 0.09 | 0.09 | 0.29 | 0.58 | 0.03 | <.0001 | 0.32 | 0.03 | <.0001 |
| Employer 2 | 0.04 | 0.02 | 0.05 | 0.49 | 0.01 | <.0001 | 0.16 | 0.01 | <.0001 |
| Employer 3 | -0.43 | 0.15 | 0.01 | 0.06 | 0.07 | 0.34 | 0.05 | 0.06 | 0.40 |
| Employer 4 | 0.01 | 0.22 | 0.96 | 0.84 | 0.05 | <.0001 | 0.29 | 0.05 | <.0001 |
| Employer 5 | 0.17 | 0.07 | 0.02 | 0.46 | 0.03 | <.0001 | 0.16 | 0.02 | <.0001 |
| Employer 6 | 0.03 | 0.04 | 0.49 | 0.16 | 0.03 | <.0001 | 0.07 | 0.03 | 0.00 |
| Employer 7 | -0.02 | 0.11 | 0.84 | 0.19 | 0.05 | 0.00 | 0.04 | 0.04 | 0.30 |
| Employer 8 | -0.01 | 0.13 | 0.92 | 0.27 | 0.05 | <.0001 | 0.16 | 0.03 | <.0001 |
| Employer 9 | -0.05 | 0.09 | 0.55 | 0.62 | 0.03 | <.0001 | 0.22 | 0.02 | <.0001 |
| Employer 10 | 0.07 | 0.05 | 0.15 | -0.05 | 0.03 | 0.08 | 0.03 | 0.02 | 0.17 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. BMI indicates body mass index; HMO indicates health maintenance organization.

### **Exhibit A3Regression Model Output Corresponding to Table 4 Adjusted Findings, Annual Emergency**

|  |  |  |  |
| --- | --- | --- | --- |
|   | Enrollees not included, 1 – 8 health risk category responses | Enrollees not included, no HRA response | Study Population  |
| Employees, n | 72,616 | 231,854 | 135,219 |
| Female, % | 11.0 | 36.5 | 54.8 |
| Age, years, % |
| 18–25 | 6.4 | 4.8 | 3.6 |
| 26–35 | 21.5 | 24.2 | 26.2 |
| 36–45 | 26.4 | 26.7 | 26.9 |
| 46–64 | 45.7 | 44.3 | 43.3 |
| Salaried, % | 42.4 | 42.2 | 42.0 |
| Charlson Comorbidity Index | 0.282 | 0.340 | 0.284 |
| Psychiatric Diagnostic Groupings | 0.170 | 0.242 | 0.224 |

Source was the authors’ analysis of data for 2016 from the IBM MarketScan Commercial Database. HRA indicates Health Risk Assessment.