Prospective Modeling of Workforce Population Health Dynamics to Inform Intervention Planning

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Session 5D: Best Practices on Using Data to Inform Policy – Quantitative Science

2nd Biennial Population and Public Policy Conference, Albuquerque, NM, February 9-10, 2019
1. **Introduction: Public Health and Population Health Management**
   - Public Health Focus and Strategy: Corporate Population Health Management *is Public Health Practice*
   - How Corporate Population Health Management Works

2. **Perspectives on Workforce Population Health Surveillance and Trend Forecasts**
   - Basic Measures: Health Surveillance and Demographic Dynamics
   - Peculiarities of Surveillance in Workforce Populations
   - Decision Science for Population Health Management: The Role of Population Forecasts

3. **A Decision-oriented Example Forecast**
   - Tobacco Prevalence Scenarios Using Decomposition and Microsimulation

4. **Further Comments on Applications in Public and Private Sectors**
   - Forecasts in Public vs. Private Sector Public Health Promotion
   - Advantages of a Cost/Benefit Perspective
Public Health Scope and Purpose

“Public health is the science of protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases. ... Public health also works to limit health disparities.”

- US Centers for Disease Control, 2019

Private Sector companies engaged in Wellness and Health Promotion are doing public health in workforce population settings.
Wellness and Health Promotion Companies Combine Deep Experience and a Scientific Approach to Health Improvement

Our single purpose at HealthFitness is to make people healthier. To help them choose better, feel better and improve their wellbeing.

- 42 Years in Business
- 4,000+ Associates Nationwide
- 180+ Clients
- $2.2 Billion in Assets (Trustmark)

Our Approach to Behavior Change

Behavior Change = Motivate + Make it Easy + Trigger + Reinforce

A Wellness and Health Promotion Value Chain

Individual
- Collect Data
- Profile
- Personalize
- Activate

Population
- Collect Data
- Assess
- Customize
- Intervene

Healthy Lifestyle
- Well doing for more people

Values
Individual Level Interventions:

- Innovative platform
- Health assessment
- Biometric screenings
- Webinars
- Health coaching
- Health advising

PARTICIPANT ENGAGEMENT
Participant experience

- AWARE
  - Platform
  - Communications
  - Incentives

- ASSESS
  - Screening
  - Health risk assessment

- ADVISE
  - Health advising

- ACTION
  - Health coaching
  - Challenges
  - On-demand
  - Live webinars
Perspectives on Workforce Population Health Surveillance
Basic Measures: Surveillance and Dynamics

**Population Health Surveillance**

- **Prevalence**
  - Cases/Population at Risk
  - Fundamental statistic
  - Crude vs. Age/gender-specific

- **Incidence**
  - Focus on new cases
  - Preventing them is key

- **Risk Difference**
  - Change in prevalence over time – includes risk-migration as well as migration dynamics.

**Population Health Dynamics**

- **Components of Change**
  - Survivorship of employed cases (St)
  - Incident cases (It) – employees who enter the “state”
  - Out-transitions (Ot) – employees who leave the “state”
  - Newly employed (Nt) or separated (St) by “state”

- **Treatment Effects/Level 2 Factors:**
  - Impacts of Interventions
  - Employer Policies
    - Eligibility and Qualification for Interventions
    - Industry Sector
    - Worksite Factors
Modeling Workforce Population Dynamics

- **Workforce Populations Are Not Separate from U.S. Population Health Dynamics**
  - Workforces are drawn from their communities and population segments.
  - Their health trajectories are determined largely by overall US health trajectories including sub-population health disparities that persist across geography, race and ethnicity, gender, and socio-economic status.

- **They Also Have Unique Properties in Terms of Health Exposures**
  - Industry and company-specific exposures
  - Work-site specific exposures
  - Differing incentive structures, eligibility, and program qualification criteria.
  - Differing insurance plans and access to care that apply to all employees as a policy.

- **Key Analytic Challenges in Modeling Workforce Population Health Dynamics**
  - A need to track population aggregates while accounting for sub-population variation that may be targeted for intervention efforts.
  - Grouped variation—**level 2 exposures**—that must be accounted for analytically in establishing program effectiveness (multi-level models)
  - Multiple i-states – fine-grained exposures that matter to demographic analysis and that are difficult to track and account for.
Real Decisions Require Understanding Real Scenarios

...forward looking
...decision-oriented
...scenario-based

...sometimes it’s hard to know which direction to take...
Traditional approaches leave us with more questions than answers...

- What do associations between programs and outcomes mean and what do they mean moving forward?
- How do the “pieces” of many studies fit together?
- How will a suite of wellness solutions impact overall population health dynamics?
- What are the most cost-effective options for *this specific workforce population*?
Decision Science in Population Health Management: The Role of Forecasts

Population Health Management Needs:

- Identification of trends and trajectories
- Expected directional impact of a suite of interventions
- Consideration of multiple alternative scenarios and solution portfolios
- Analyses across strategic, operational, and tactical scales
- Cost-benefit assessments

Population Health Forecasts Provide:

- Seamless integration of historical estimates and forecasts of future trends.
- Ability to assess overall impact of multiple concurrent intervention plans
- Scenario-based forecasts assist in weighing alternatives and cost/benefit analyses
- System Dynamic and microsimulation approaches support scaled analyses.
- Bottom line estimates can be directly built into a single framework on a per-capita basis
Projected Tobacco Use Prevalence: Demographic Decomposition and Microsimulation
Tobacco Use in the Workplace: Basic Epidemiology and Analytic Approaches
Tobacco Use Epidemiology in the United States

- As of 2015, 15.5% of U.S. adults were current smokers (Jamal et. al., 2018)
- Prevalence is decreasing over time (~1-2% per year)
- In 2015, 68.0% of current smokers surveyed in the Tobacco Use Supplement of the Current Population Survey reported wanting to quit
- 54.5% of them had tried – but only 7.4% of them were successful (Babb et. al., 2017)
- Younger smokers are more likely to quit than older ones – perhaps longer history of use?
- Smokers are more likely to quit when pharmacotherapy, cessation counseling, or a combination of both are utilized (Hudmon et. al., 2010; Aubin et. al, 2011)
- As of 2014, the CDC estimated that 42.1 million annual deaths were directly attributable to tobacco use.
Tobacco Use in the Workplace: Cessation Drives Large-Scale Savings

• Berman et. al. (2013) estimated a net savings of $6K annually in medical claims expenditures for each quitter

• Health coaching has been suggested to be an effective way to reduce tobacco use in the workplace (Sorensen et. al., 2007, 2010)

• Health coaching costs $450 per year per employee: Potential ROI of 13/1

Empowered Health Coaching™ participants are 51% more likely to quit tobacco than non-participants.

It Pays to Kick the Habit: MMA star Holly Holm demonstrates on the Cigarette Smoking Man
Health Promotion Processes are Complex

Client Population Time 1

Profile (Assess & Prioritize)

High Risk

Pos Risk Migrants

Success Rate

Neg Risk Migrants

Deterioration Rate

Low Risk

No Program

Personalize (Optimized Match)

Participation Rate

Non-Participants

Participants

Program

Risk Non-Migrants

Success Rate

Pos Risk Migrants

Success Rate

Client Population Time 2

Predicted Client Population Time 2

Client Population Time 1

Predicted Client Population Time 2

Value

Population Level Risk Trends
Risk Difference (RD = R\text{exp} - R\text{obs})

Flow of Stock

Converter Rate

Stock (Process)

Outcome Metric

Stock

Stock (Projected)

Population

Level Risk

Trends

Risk Difference

(\text{RD} = \text{R}^{\text{exp}} - \text{R}^{\text{obs}})

Value

Predicted Client Population Time 2

Value

Profile

Personalize

Activate

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Decomposition of Risk Difference Simplifies and Focuses Analysis

\[ RD = \text{Prev}_{t1} - \text{Prev}_{t0} \]
Drivers of Population Health Dynamics

- Population
  - Risk Migration
  - Retained Employees
  - Separating Employees
  - New Employees
Risk Migration in Retained Employees

Can Be Impacted by Programs/Interventions
Migration: New and Separating Employees

Cannot Be Impacted by Programs – External Effect
Decomposition of Risk Difference
Simplifies and Focuses Analysis

\[ RD = \text{Prev}_{t1} - \text{Prev}_{t0} \]

\[ RD = [ \text{Prev}_{t0} + (I_t - O_t) + (S - Q) ] - \text{Prev}_{t0} \]

\[ RD = [ \text{Prev}_{t0} + (I_t - O_t) + ((S_c + S_{nc}) - (Q_c + Q_{nc})))] - \text{Prev}_{t0} \]

\[ Q_c = N_s \times p_s \times q_{c,s} \quad \text{[Kernel]} \]

\[ RD_{DC} = RD - [N_s \times p_s \times q_{c,s}] \]
Microsimulation Allows Tuning of System Parameters and Evaluation of Scenarios

- **Current State**
  - Program participation: ~21% participation in coaching
  - Program effectiveness: coaching participants are 51% more likely to cease tobacco use

- **Scenarios:**
  - Project “current-state” dynamics forward five years
  - Tune participation levels up or down... predict new values using machine learning model. Re-compute risk difference. Re-project future states.
  - Leave program effectiveness constant
i-states and p-states in Demographic Analysis

- Caswell and John’s “Individual-Based Models in Demography” (1992)

i-state
Eg. \( p(i) = f(x) \)

p-state vectors
Eg. ASFR, ASMR, \( e_0 \)

Population Dynamic Models
Microsimulation-based Forecasts

CART Prediction = Branch 1 + Branch 2 + Branch 3

Boosted Regression Tree model is trained to predict 2016 tobacco use status

Coaching participation is “up-tuned” and time 2 status is re-predicted

Risk Difference statistic is updated

Population is re-projected
Results: Five-year Forecasts of Tobacco Use Prevalence Under Coaching Participation Scenarios
## Baseline Tobacco Prevalence by Five Year Age-Groups (Index Population -- 100,000)

<table>
<thead>
<tr>
<th>Five Year Age Groups</th>
<th>Male</th>
<th>Female</th>
<th>Age-Specific Prevalence</th>
<th>Risk Difference&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Tobacco Non-Tobacco Total Tobacco Non-Tobacco</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>20 to 24</td>
<td>956  77  880</td>
<td>860  45  816</td>
<td>0.080</td>
<td>0.052</td>
</tr>
<tr>
<td>25 to 29</td>
<td>4,125 219 3,906</td>
<td>3,505 167 3,339</td>
<td>0.053</td>
<td>0.048</td>
</tr>
<tr>
<td>30 to 34</td>
<td>5,744 342 5,402</td>
<td>4,976 221 4,755</td>
<td>0.060</td>
<td>0.045</td>
</tr>
<tr>
<td>35 to 39</td>
<td>6,339 419 5,920</td>
<td>5,398 304 5,094</td>
<td>0.066</td>
<td>0.056</td>
</tr>
<tr>
<td>40 to 44</td>
<td>6,592 391 6,200</td>
<td>5,513 305 5,208</td>
<td>0.059</td>
<td>0.055</td>
</tr>
<tr>
<td>45 to 49</td>
<td>7,441 459 6,983</td>
<td>6,257 389 5,868</td>
<td>0.062</td>
<td>0.062</td>
</tr>
<tr>
<td>50 to 54</td>
<td>7,923 481 7,442</td>
<td>6,967 527 6,440</td>
<td>0.061</td>
<td>0.076</td>
</tr>
<tr>
<td>55 to 59</td>
<td>7,701 514 7,187</td>
<td>6,834 521 6,313</td>
<td>0.067</td>
<td>0.076</td>
</tr>
<tr>
<td>60 to 64</td>
<td>5,175 305 4,870</td>
<td>4,439 266 4,173</td>
<td>0.059</td>
<td>0.060</td>
</tr>
<tr>
<td>65 Plus</td>
<td>1,818 72 1,746</td>
<td>1,433 67 1,367</td>
<td>0.039</td>
<td>0.047</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53,815 3,278 50,538</td>
<td>46,185 2,813 43,372</td>
<td>0.061</td>
<td>0.061</td>
</tr>
</tbody>
</table>

<sup>1</sup> Year over year risk differences suggested larger than expected increases in prevalence when compared to national averages. To safeguard against bias, risk differences were estimated as the posterior mean of the Bayes estimates combining the observed estimate with an indirect estimate based on national averages.
## Five Year Age/Gender-specific Trends in Tobacco Prevalence

### Current Levels of Coaching Enrollment

<table>
<thead>
<tr>
<th>Five Year Age Groups</th>
<th>Age-Specific Prevalence Y0</th>
<th>Annual Risk Difference</th>
<th>Age-Specific Prevalence Y5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>20 to 24</td>
<td>0.080</td>
<td>0.052</td>
<td>-0.004</td>
</tr>
<tr>
<td>25 to 29</td>
<td>0.053</td>
<td>0.048</td>
<td>-0.006</td>
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<td>0.045</td>
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<td>0.056</td>
<td>-0.001</td>
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<tr>
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<td>0.059</td>
<td>0.055</td>
<td>0.003</td>
</tr>
<tr>
<td>45 to 49</td>
<td>0.062</td>
<td>0.062</td>
<td>-0.001</td>
</tr>
<tr>
<td>50 to 54</td>
<td>0.061</td>
<td>0.076</td>
<td>-0.004</td>
</tr>
<tr>
<td>55 to 59</td>
<td>0.067</td>
<td>0.076</td>
<td>-0.006</td>
</tr>
<tr>
<td>60 to 64</td>
<td>0.059</td>
<td>0.060</td>
<td>-0.009</td>
</tr>
<tr>
<td>65 Plus</td>
<td>0.039</td>
<td>0.047</td>
<td>-0.003</td>
</tr>
<tr>
<td>Total</td>
<td>0.061</td>
<td>0.061</td>
<td>-0.003</td>
</tr>
</tbody>
</table>

### Five Year Trends in Tobacco Usage -- Current Coaching Levels

- **Men Y0**: 6%
- **Men Y5**: 4%
- **Women Y0**: 6%
- **Women Y5**: 1%
### Five Year Age/Gender-specific Trends in Tobacco Prevalence

#### 20 Percentage Point Increase in Coaching Enrollment

<table>
<thead>
<tr>
<th>Five Year Age Groups</th>
<th>Age-Specific Prevalence Y0</th>
<th>Annual Risk Difference</th>
<th>Age-Specific Prevalence Y5</th>
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<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>20 to 24</td>
<td>0.080</td>
<td>0.052</td>
<td>-0.015</td>
</tr>
<tr>
<td>25 to 29</td>
<td>0.053</td>
<td>0.048</td>
<td>-0.013</td>
</tr>
<tr>
<td>30 to 34</td>
<td>0.060</td>
<td>0.045</td>
<td>-0.010</td>
</tr>
<tr>
<td>35 to 39</td>
<td>0.066</td>
<td>0.056</td>
<td>-0.007</td>
</tr>
<tr>
<td>40 to 44</td>
<td>0.059</td>
<td>0.055</td>
<td>-0.002</td>
</tr>
<tr>
<td>45 to 49</td>
<td>0.062</td>
<td>0.062</td>
<td>-0.007</td>
</tr>
<tr>
<td>50 to 54</td>
<td>0.061</td>
<td>0.076</td>
<td>-0.009</td>
</tr>
<tr>
<td>55 to 59</td>
<td>0.067</td>
<td>0.076</td>
<td>-0.011</td>
</tr>
<tr>
<td>60 to 64</td>
<td>0.059</td>
<td>0.060</td>
<td>-0.013</td>
</tr>
<tr>
<td>65 Plus</td>
<td>0.039</td>
<td>0.047</td>
<td>-0.005</td>
</tr>
<tr>
<td>Total</td>
<td>0.061</td>
<td>0.061</td>
<td>-0.009</td>
</tr>
</tbody>
</table>

#### Five-year Trends in Tobacco Usage -- Plus 20% Points in Coaching Levels

- **Men Y0**: 6%
- **Men Y5**: 2%
- **Women Y0**: 6%
- **Women Y5**: 0%
Projected Returns on Investment: 20-Point Participation Increase

Tobacco Users

Coached

- N = +800
- 23.31% Quit
- 67.63% No Quit

ROI = 5.44 (Male)
ROI = 4.47 (Female)

Not Coached

- 77.69% Quit
- 21.40% No Quit

ROI = n*p*Q*($6000-$450)
## Realized Return on Investment for Increased Health Coaching Enrollment

<table>
<thead>
<tr>
<th>Five Year Age Group</th>
<th>Participation + 20 Percentage Points (43.31%)</th>
<th>Realized Savings</th>
<th>Realized Expenses</th>
<th>Realized ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>20 to 24</td>
<td>$224,879.11</td>
<td>$27,064.43</td>
<td>$13,946.52</td>
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<tr>
<td>25 to 29</td>
<td>$635,659.09</td>
<td>$77,688.17</td>
<td>$57,318.39</td>
<td>8.18</td>
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<tr>
<td>30 to 34</td>
<td>$838,491.93</td>
<td>$125,329.37</td>
<td>$85,221.63</td>
<td>6.69</td>
</tr>
<tr>
<td>35 to 39</td>
<td>$867,496.04</td>
<td>$154,991.19</td>
<td>$108,074.72</td>
<td>5.60</td>
</tr>
<tr>
<td>40 to 44</td>
<td>$722,414.53</td>
<td>$144,276.30</td>
<td>$108,027.04</td>
<td>5.01</td>
</tr>
<tr>
<td>45 to 49</td>
<td>$895,339.15</td>
<td>$160,950.01</td>
<td>$137,613.75</td>
<td>5.56</td>
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<tr>
<td>50 to 54</td>
<td>$761,834.57</td>
<td>$155,653.91</td>
<td>$183,576.06</td>
<td>4.89</td>
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<tr>
<td>55 to 59</td>
<td>$829,376.61</td>
<td>$168,414.56</td>
<td>$192,021.38</td>
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<tr>
<td>60 to 64</td>
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<td>$96,406.10</td>
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<tr>
<td>65 Plus</td>
<td>$81,104.65</td>
<td>$24,533.35</td>
<td>$32,810.31</td>
<td>3.31</td>
</tr>
<tr>
<td>Total</td>
<td>$6,178,388.33</td>
<td>$1,135,307.41</td>
<td>$1,027,607.80</td>
<td>5.44</td>
</tr>
</tbody>
</table>
Summary of Analysis

- Tobacco use is diminishing over time in our Book of Business study sample.
  - This matches overall national trends

- Increases in health coaching will accelerate this trend, hopefully eliminating tobacco use in our workforce population sample once and for all.
  - Huge public health benefits: reduce cancer deaths, heart disease, lung disease, etc.
  - Benefits not considered, necessarily, as a contribution of the private sector to overall US public health efforts

- Costs of increased coaching are more than offset by the returns in terms of claims reduction for tobacco-related medical expenditures covered by the employer
  - Potentially 13/1 – Realized 4.47 to 5.54
Further Comments on Applications in Public and Private Sectors
Public vs Private: A False Dichotomy

- 94% of U.S. employees working for companies with greater than 200 employees have access to wellness and health promotion programs.

- Wellness and health promotion programs have a demonstrated track record of improving employee health outcomes across a range of risk factors related to chronic disease:
  - Tobacco cessation (Sorenson et al., 2007, 2010)
  - Physical activity levels (Haskell et al., 2007; Meyer et al., 2010; Gemson et al., 2008; Proper et al., 2004; Anderson et al., 2009)
  - Dietary Quality (Engbers et al., 2005; Sorenson et al., 1996; Matson-Koffman et al., 2005; Levin et al., 2010; Hope et al., 2010; Diabetes Program Prevention Group, 2002)

- Wellness and health promotion strategies are a major public health strategy funded entirely by private sector expenditures: one that has a potentially unprecedented scope and reach and is typically not considered in standard public health strategies.

- This suggests that government and private sector public health practitioners should be in greater strategic alignment than they currently are.
Analytic Alignment Across the Sectors

• The methods presented here could be applied to public health – but government microdata sources would be required for most applications

• The example presented here covers a single solution: health coaching

• The framework presented, however, would allow simultaneous tuning of multiple interventions and combinations of interventions with a single overall strategy (solution portfolio)

• With per-capita cost and benefit assessments the norm in industry – this allows straightforward cost/benefit analysis

• Cost/benefit analysis *always improves service delivery* and it would do so in the government sector as well (standard public health strategies)

• Therefore, the methods presented here have large potential for application within government public health settings where microdata is abundant
### How Businesses Think About Intervention Portfolios (so should government agencies)

#### Example Cost/Benefit Calculator for Tobacco Cessation Solution Portfolios

<table>
<thead>
<tr>
<th>Solution Portfolios</th>
<th>Projected Cases (3 yr)</th>
<th>Enrollment Rate</th>
<th>Risk Reduction</th>
<th>Reduction in Cases</th>
<th>Per-capita Cost</th>
<th>Total Expenditure</th>
<th>Per-capita Cost Offset</th>
<th>Total Cost Offset</th>
<th>E (ROI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1</td>
<td>4500</td>
<td>0.45</td>
<td>0.10</td>
<td>203</td>
<td>$85.00</td>
<td>$172,125.00</td>
<td>$5,915.00</td>
<td>$1,197,787.50</td>
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</tr>
<tr>
<td>Solution 2</td>
<td></td>
<td>0.35</td>
<td>0.15</td>
<td>236</td>
<td>$110.00</td>
<td>$173,250.00</td>
<td>$5,890.00</td>
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<td>8.0</td>
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<tr>
<td>Solution 3</td>
<td></td>
<td>0.15</td>
<td>0.35</td>
<td>236</td>
<td>$450.00</td>
<td>$303,750.00</td>
<td>$5,550.00</td>
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<tr>
<td>Solution 4</td>
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<td>0.05</td>
<td>113</td>
<td>$25.00</td>
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<td>Solution 1-2</td>
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<td>0.25</td>
<td>450</td>
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<td>$351,000.00</td>
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<td>$882,000.00</td>
<td>$5,440.00</td>
<td>$4,284,000.00</td>
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Real-world decisions look something like this:
- This particular company must decide what to do under a budget constraint, balancing the reach of the program with the expense, while ensuring that the program is “in the black” with a positive ROI.
- Some cheap programs have a positive ROI, but do little to impact health.
- Others are expensive, and while they have high-reach and a positive ROI, they may simply be out of reach in terms of the sunk-cost of setting up the program.

A portfolio including Solutions 1 and 3 appears feasible.

The most impactful portfolio—utilizing all Solutions—is out of reach.
Acknowledgements and Contact Info

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• For further information, contact:

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About HealthFitness

HealthFitness, a Trustmark company, is an award-winning provider of health management, corporate fitness and condition management solutions. With more than 40 years of experience, it is URAC- and NCQA-accredited and a proven leader and partner for infusing a culture of health. HealthFitness maximizes client results through personalized interaction and a science-based approach to on-site program management, engagement and prevention. Parent company Trustmark provides a full spectrum of employee benefits to improve well-being through better health and greater financial security. For more information on HealthFitness, visit www.healthfitness.com.