Benefit-Cost Analysis

Diabetes Education Recognition Program

North Carolina Diabetes Prevention and Control

Department of Health & Human Services

Conducted
By
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Introduction

Over the past decade, numerous benefit-cost analyses have been conducted on diabetes education and self-management programs. For example, a recently published article identified twenty-six (26) papers that addressed this issue. More than half (18) of the 26 papers identified by the literature review reported findings that associated diabetes education (and disease management) with decreased cost, cost-saving, cost-effectiveness, or positive return on investment (ROI). Four studies reported neutral results, 1 study found that costs increased, and 3 studies did not fit into these categories.

Despite the plethora of evaluations that have been conducted on diabetes education and self-management programs throughout the United States, only a couple have reportedly been conducted in North Carolina. Both of these studies focused primarily on measuring the impact of diabetes education and self-management programs on selected behavioral and/or clinical indicators such as blood lipids and hemoglobin A1c, aspirin use, foot health, dietary practices, and diabetes self-care practices. Neither of the preceding studies included a financial benefit vs. cost analysis. Thus, the following analysis may represent the first of its kind in North Carolina that translates hemoglobin A1c changes into a financial value.

The Burden of Diabetes in North Carolina

In North Carolina, nearly 1 of 10 adults has diabetes. In fact, the prevalence of adult diabetes has more than doubled from 4.5% in 1995 to 9.8% in 2010 as shown in figure 1.

Currently, it is estimated that more than 700,000 adults have diabetes and an additional 451,000 have pre-diabetes. Statewide, diabetes is the 7th leading cause of death among all adults, the 4th leading cause of death for African-Americans, and is slightly more prevalent in females than males.

As expected, the growing prevalence of diabetes in North Carolina translates into rising medical care costs. For example, diabetes-related health care expenses are up to 3.5 times
higher for people with diabetes than those without the condition. Moreover, the total cost of diabetes in North Carolina is approximately $7.31 billion (2011 dollars) per year including $1.41 billion in medical care costs and $5.90 billion in lost productivity.

Figure 1. Prevalence of diabetes among adults in North Carolina.

The most recent Behavioral Risk Factor Surveillance Survey [2010] indicated 9.8% of North Carolina adults have been diagnosed as having diabetes mellitus.

Diabetes Education Recognition Program

Recognizing the importance of attacking the growing statewide prevalence of diabetes, the North Carolina Diabetes Prevention and Control division established the **Diabetes Education Recognition Program** (DERP) in 2006. DERP is designed to provide adults who have been clinically classified as having type 1 or type 2 diabetes with a series of professionally taught educational sessions to help them improve their diabetes status. Upon being enrolled in DERP, participants engage in a one-on-one individual class that provides an orientation and baseline A1c clinical measurement in addition to other clinical assessments (e.g., blood pressure, foot exams, etc.). Then they engage in 8 hours of group classes taught by either a registered dietitian, registered nurse, or a registered pharmacist. All classroom information is approved by the American Diabetes Association. Finally, three (3) months after attending their last group class session, participants have a follow-up A1c clinical measurement. The average timeframe from the initial orientation to the completion of the follow-up clinical screening is 4 to 6 months.
Outcome Variables

DERP is designed to provide diabetes self-management information to North Carolina adults who have been diagnosed with diabetes. The ultimate goal of these interventions is to improve each participant’s ability to control their condition.

In order to determine if DERP is achieving its designated goal, this benefit-cost analysis centered on one major outcome variable: **hemoglobin A1c level**. In particular, hemoglobin A1c level was selected as the **primary clinical outcome** variable because it (1) is arguably the best biometric indicator of a person’s diabetes status,7 (2) can be easily measured at various intervals in a program like DERP, and (3) can be subjected to a financial cost value (e.g., medical care cost).1 As a biometric indicator, hemoglobin A1c is considered to be a particularly accurate diagnostic measure for diabetes, according to recent recommendations from the American Diabetes Association (ADA).7 Specifically, the new ADA recommendations, which are revised every year to reflect the most current available scientific evidence, indicate that an A1c level of:

- 5 percent or below represents *diabetes-free status*
- 5.7 – 6.4 percent represents a “pre-diabetic” status
- 6.5 percent or higher represents a clinical diagnosis of *diabetes*

Moreover, the ADA recommends that most people with diabetes maintain a goal of keeping A1c levels at or below 7 percent in order to properly manage their disease.

Target Population

The target population of North Carolina adults selected for this analysis (1) were enrolled in DERP between 2007-2010, (2) have either type 2 non-insulin –or- type 2 insulin-treated diabetes, and (3) have both baseline and impact A1c measurements. Based on a review of various participant data sheets, **310 participants met all of the preceding criteria.**
In population wide studies such as this one, it is advisable to include as many individuals from as large a geographic area as possible to minimize the potential impact that certain factors (e.g., social, economic, environmental, cultural, demographic, etc.) may have on the primary outcome variable. Participants included in this analysis reside in 18 counties throughout North Carolina such as:

- Cabarras
- Chatham
- Clay
- Davie
- Duplin
- Guilford
- Jackson
- Johnston
- Jones
- Nash
- Pamlico
- Pender
- Pitt
- Robeson
- Sampson
- Union
- Wake
- Wilkes

Thus, given the wide geographic area represented by counties in which participants reside, it is likely that any potential unintended influence of external forces on A1c level would be minimal.
**Results**

Baseline A1c and impact A1c levels were compared in 310 participants who met all of the outcome criteria. Within this group of participants:

- 235 (75.8%) had lower A1c levels at impact
- 13 (4.2%) had the same baseline and impact A1c levels, and
- 62 (20%) reported higher A1c levels at impact

Overall, a comparison of group-wide baseline A1c vs. impact A1c levels is shown in figure 2. This comparison shows that participants dropped their A1c levels by 13% over the course of their participation. Yet, a more revealing look at baseline vs. impact A1c levels is shown in figure 3 that incorporates three levels of values. Of the three values listed in figure 3, **median** values are arguably the most accurate indicator of A1c baseline and impact values. This is primarily due to the fact that the statistical computation used to compute these values effectively mitigates the inflation or deflation caused by “outliers” (e.g., persons with exceptionally high or exceptionally low A1c levels). For example, 59 participants displayed baseline A1c levels over 10 compared to only 18 participants who displayed such levels at impact. Thus, there was considerably more volatility (e.g., inflated A1c levels) in the baseline profile than in the impact profile. Using a median computation in such cases effectively buffers or minimizes the impact of this one-sided volatility. Understandably, researchers generally place more stock in median values since they reflect a more accurate view of a group’s *overall* performance.\(^8\)
Figure 2. Unweighted median group-wide baseline and impact A1c levels, compared to the desired level.

Figure 3. Unweighted mean, median, and mode baseline and impact A1c levels.

**Code**

*Mean* = average [sum of all scores - divided by - number of scores]

*Median* = score that represents the 50th percentile because it falls exactly between the 50% highest and the 50% lowest scores.

*Mode* = the most frequent or common score.

*Unweighted* = does not factor in the proportionately weighted differences between participants with lower A1c levels vs. those with higher levels vs. those with the same levels.
Based on ADA guidelines listed earlier on page 4, an A1c level of 5% was used as the desired metric value to reflect a diabetes-free risk level. Thus, in order to measure the impact of DERP on A1c levels, the following equation was used:

\[
\frac{\text{Baseline A1c} - \text{Impact A1c}}{\text{Baseline A1c} - \text{Diabetes-free risk}} = \text{Impact} \% *
\]

* Degree of improvement toward achieving diabetes-free status.

Applying median A1c levels to the preceding formula generates the following impact:

\[
\frac{\text{Baseline A1c} [7.7] - \text{Impact A1c} [6.7]}{\text{Baseline A1c} [7.7] - \text{Diabetes-free risk} [5.0]} = 37.03\% \text{ [unweighted]}
\]

A comparison of median baseline vs. impact A1c levels suggests that DERP participants improved their individual diabetes risk level by more than 37 percent. However, this median-driven outcome actually reflects an unweighted percentage impact and does not fully take into account at least three factors that can affect the actual impact. First, this particular approach does not account that nearly 1 of every 4 (24.2%) participants either had increased or static A1c levels. Second, it does not account for the widely variable changes between individuals within these two sectors. Third, it does not factor in that nearly four times as many participants reported extraordinarily high (>10) levels of A1c at baseline vs. impact. Thus, by statistically factoring these three factors into the equation, a weighted diabetes risk reduction impact of 17.17% was calculated. Simply put, participants lowered their level of excess diabetes risk by more than 17% or about one-sixth (1/6th) of their initial [baseline] level.
Benefit-Cost Analysis

Since a reduction in A1c level lowers a person’s overall health risks,\textsuperscript{1,5,7} it is likely that individuals achieving A1c reductions will reduce their need for medical care services.\textsuperscript{5} Consequently, any reduction in such services leads to some level of **medical care cost-avoidance.** Of course, it is impossible to determine what level of actual cost-avoidance benefits will presumably occur in the future without monitoring actual medical care expenses of each participant. However, published cost norms suggest that medical care cost-avoidance benefits associated with A1c improvements can be substantial.\textsuperscript{5,6,9} Yet, in order to determine the estimated medical care cost-avoidance “benefit” in this sample of DERP participants, it was necessary to first establish a realistic per capita annual medical care cost of diabetes. Drawing upon two independent databases,\textsuperscript{6,9} the estimated per capita **medical care** cost of type 2 diabetes in North Carolina is approximately $2,647 per year. Thus, applying reported DERP participation rates, A1c baseline vs. impact levels, and per capita diabetes-specific medical care costs, an annual medical care cost-avoidance value was calculated as follows:

<table>
<thead>
<tr>
<th>Net % drop in A1c level</th>
<th>\text{.1717 (17.17%)}</th>
</tr>
</thead>
<tbody>
<tr>
<td># of participants*</td>
<td>\times 310</td>
</tr>
<tr>
<td>Per capita annual medical cost for diabetes</td>
<td>\times $2,647</td>
</tr>
<tr>
<td>Approximate cost-avoidance value (“benefit”)</td>
<td>$140,892</td>
</tr>
</tbody>
</table>

*All 310 participants are included in this equation because the net percentage drop (17.17\%) factored in baseline and impact A1c levels for all of the 24.2\% of the participants who reported either an increased and stationary A1c level.
Once the preceding medical care cost-avoidance ["benefits"] portion of this analysis had been completed, the “cost” side of the analysis was conducted. The **cost side** of the benefit-cost analysis reflects all direct costs associated with the development, implementation, and on-going operation of DERP. Based on information provided by DERP administrators, the per capita programming cost is estimated to be approximately $375 per year. Consequently, group-wide programming costs are estimated to be approximately $116,250 per year:

\[
\begin{align*}
\text{# of Participants} & \quad 310 \\
\text{Per capita cost} & \quad \times \ 375 \\
\text{Total cost} & \quad \$116,250
\end{align*}
\]

**Benefit-cost Comparison**

Based on the preceding benefits and costs, the following benefit-to-cost ratio and associated return-on-investment (ROI) value are attributed to DERP:

\[
\begin{align*}
\text{Benefits} & \quad \$\ 140,892 & \quad \$\ 1.21 \\
\text{Cost} & \quad \$\ 116,250 & \quad \$\ 1.00
\end{align*}
\]

\[
\frac{\$\ 140,892}{\$\ 116,250} = 1.21 = +21\% \text{ ROI}
\]

In essence, it appears that DERP generates $1.21 in medical care cost-avoidance benefits for every $1 spent on this intervention.
Present-value Adjustment

In addition to the preceding BCA, DERP-generated cost and benefit values were subjected to a present value adjustment (PVA). PVA is often used in econometric analyses to determine the approximate financial value of today’s benefits and costs in the future. Essentially, PVA provides stakeholders and decision-makers with information to gauge how today’s market forces (e.g., medical care inflation) affect benefit-cost values over a designated period of time. For example, programmatic cost items (e.g., personnel, equipment, etc.) tied to DERP are discounted at a lower rate than program-generated benefits (e.g., medical care cost-avoidance) since the former could be used immediately in an alternative strategy (e.g., deposited into an interest-bearing savings account) while the latter may not accrue until the intervention makes a definitive impact – which may take months or years. PVA is particularly valuable for gauging how long a program that may be financially successfully in the short-term can sustain a positive benefit-to-cost ratio before benefits depreciate at or below the cost value.

Table 1 illustrates PVA values over a 5-year period of time from 2012 to 2016. The year-to-year comparison of benefits to costs suggests that DERP’s financial impact (in year 2011 values) would evaporate in 2014 if participants do not maintain their initial baseline-to-impact A1c improvements.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit*</td>
<td>2011</td>
<td>$140,892</td>
<td>$129,762</td>
<td>$119,510</td>
<td>$110,069</td>
<td>$101,374</td>
</tr>
<tr>
<td>BC ratio</td>
<td>2011</td>
<td>1.212:1</td>
<td>1.135:1</td>
<td>1.063:1</td>
<td>.996:1</td>
<td>.933:1</td>
</tr>
</tbody>
</table>

* Benefit dollars are discounted 7.9% per year (Source: The Henry J. Kaiser Family Foundation, State Health Facts. Average Annual Percent Growth in Health Care Expenditures in North Carolina, 1991-2009)

** Cost dollars are discounted 1.675% per year based on average annual wage/salary increases for state employees from 2001-2010. (Source: State of North Carolina 2011 Compensation & Benefits Report, Office of State Personnel, History of Legislative Increases for N.C. State Employees, 1992-2010)
**Limitations**

There are several limitations that should be noted when considering the full context of this analysis and its results. For example:

- Benefit-cost and ROI values are attributable solely to the aggregate group of 310 participants who met three specific criteria, and not necessarily to other DERP participants who *may* have also lowered their impact A1c levels that could not be confirmed in the absence of impact data.
- The findings apply solely to participants who met three specific criteria residing only in the 18 counties listed in this analysis, and not necessarily to other DERP participants in other counties who *may* have also lowered their impact A1c levels that could not be confirmed in the absence of impact data.
- Variations in how the group sessions were administered (e.g., eight, 1-hour sessions vs. four, 2-hour sessions, etc.) or any differences in teaching or communication styles between the course instructors were not taken into account.

**Overall, it appears that DERP has generated a favorable ratio of benefits to costs in the time frame designated within this analysis.**
References

Appendix A

BCA Framework

The primary purpose of benefit-cost analysis (BCA) is to determine whether a program is worth its cost. In reality, BCA is an econometric tool that factors in the monetary value of everything that can be tangibly measured and quantified. By and large, the monetary value of a project rests on two fundamental postulates:

Postulate 1: The social value of an intervention is the sum of the value of the project [e.g., DERP] to the individual members of society (e.g., North Carolina citizens)
Postulate 2: The value of an intervention to an individual is equal to his (fully informed) willingness to pay for the intervention.

Making value judgments about the desirability of economic states is the thrust of welfare economics and the choice of a decision criterion is critical. A guiding rule in formulating criteria, at least in Western society, is that each individual’s preferences must (somehow) count in the evaluation of alternative economic states. While there are four popular decision criteria (Unanimity, Pareto Superiority, Majority Rule, Potential Pareto Superiority), the criterion used in benefit-cost analysis is the Potential Pareto Superiority criterion. It states that an increase in general welfare occurs if those that are made better off and still from some change could, in principle, fully compensate those that are made worse off and still achieve in welfare improvement. While this criterion provides the basis for the quantitative part of BCA, it poses problems in that potential compensation may not be actual compensation.

Operationally, BCA compares intervention costs and any benefits as a ratio:

\[
\text{Benefit} \\
\text{B/C Ratio} = \frac{\text{Benefit}}{\text{Cost}}
\]

Obviously, BCA is most appropriate when both benefits and costs can be tangibly measured in monetary terms. Nevertheless, some researchers keenly warn that quantification shouldn’t be the sole basis for performing a benefit-cost analysis. They contend that just because some important factors are not easily measured, they should not be ignored or given a lesser value than factors that can be measured. For example, how can the human pain and suffering by people with severe back pain or chronic depression be accurately quantified? In essence, BCA doesn’t portend to introduce rigor and quantification when data originate on subjectivity, imprecision, or where quantification is not feasible. However, when costs and benefits can be quantified, a BCA can be used to judge the worth of a single intervention or provide comparisons on two or more interventions.
Overall, benefit-cost analysis provides meaningful data to the extent that any benefits can be accurately measured. Yet such noble benefits as human lives saved, preventing heart attacks, or easing chronic back pain are not easily translated into precise numbers. Interestingly, a human life was valued to be worth a mere $5,000 nearly a Century ago. Moreover, should a monetary value even be placed on a human life? Although it is possible to calculate the direct costs of treating a heart attack victim or to discount a person’s future job earnings lost from a disability, try to imagine the technical and ethical implications of using a benefit-cost analysis beyond its intended scope.

The **cost side** of a benefit-cost analysis involves calculating the costs of all resources used in planning and implementing an intervention. In contrast, the **benefit side** of the equation involves calculating the monetary value of any **positive outcomes** [e.g., A1c levels dropping after DERP becomes operational] that can be quantified. Measuring benefits requires a number of different techniques. The effects of direct benefits are usually measurable using standard accounting reports and conventional financial analysis. However, the effects of indirect benefits can be very large, though difficult to prove using conventional cost-accounting.

Obviously, in order to prepare a workable BCA framework, it is essential to **identify** and **measure** benefits and costs. A sample listing of typical benefits and costs is as follows:

<table>
<thead>
<tr>
<th>Typical Benefit Outcomes</th>
<th>vs.</th>
<th>Typical Cost Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer injuries/accidents</td>
<td>Facilities/equipment</td>
<td></td>
</tr>
<tr>
<td>Lower health care cost</td>
<td>Personnel</td>
<td></td>
</tr>
<tr>
<td>Fewer sick leave absences</td>
<td>Health screenings</td>
<td></td>
</tr>
<tr>
<td>Greater productivity</td>
<td>Medical care treatment</td>
<td></td>
</tr>
<tr>
<td>Higher quality of life</td>
<td>Prescription drugs</td>
<td></td>
</tr>
</tbody>
</table>

Presumably, calculating “direct” benefits associated with an intervention should be relatively simple. However, before any benefit can be calculated, evaluators must select benefit variables that are accessible and measurable, and feel confident that any **benefit outcome** is due, to some defensible extent, to the **intervention**. After all costs and benefits have been identified and measured, the two categories are compared monetarily. In most cases, the goal is to determine the “net
benefit” of a particular intervention. In essence, if the value of the *benefits minus the value of the costs is positive*, then the analysis would indicate that the intervention is financially "worth the effort." The net benefit of any intervention can be calculated as follows:

Net Benefit = \[ \sum \text{L$} + \sum \text{GP} + \sum \text{PI} \] - C

where:

\( \sum \text{L$} \) (sometimes called the *direct benefit*) stands for the reduction in medical care expenses due to reducing the factors (e.g., type 2 diabetes) that drive such expenses. For example, if a traditionally high rate of health care encounters can be reduced, then some portion of overall spending [by all payers] on outside medical care services will be avoided.

\( \sum \text{GP} \) stands for the increase in general productivity, leading to greater output and income. For example, by reducing the incidence of type 2 diabetes, an employee’s performance capabilities can be increased and, thereby, enable him/her to *actually earn* a larger portion of their paycheck.

\( \sum \text{PI} \) stands for the gain in working income due to reduced illness and injury and their effects on absenteeism (lost income). For example, managing a chronic condition such as diabetes via medication and healthy lifestyle actions directly benefits the affected employee by (1) avoiding time away from work (e.g., potential lost income) to seek health care, (2) reducing the prospects that such a condition will lead to subsequent absences and (3) enhancing the odds that, even in the event that an absence does ensue, the affected employee will have a shorter recovery time and return to functional work in a timely manner.

C stands for the cost of the intervention [e.g., DERP].