

Behavioral interventions and cost-effectiveness analysis

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Abstract

Behavioral health interventions are often gauged with a dichotomous outcome, “success” or “failure.” Hidden by this dichotomy is a series of behavior changes that can be followed with the Transtheoretical Model (stages of change). There has been little consideration, however, about whether this information can and should be used in cost-effectiveness analysis. We review the stages of change model and its applications to behavioral health interventions. We then discuss analytical methods for including stages of change, or similar behavior change models, in cost-effectiveness analysis (CEA). This is typically not done but it may be critical for study design and for interpreting CEA results. Published by The Institute For Cancer Prevention and Elsevier Inc.

Keywords: Cost-effectiveness analysis; Stages of change; Transtheoretical Model; Behavioral interventions; QALYs

Introduction

Behavioral health interventions encourage individuals to modify their existing unhealthy behaviors and to adopt healthy behaviors. These studies are often gauged with a dichotomous outcome, “success” or “failure.” Mammography screening, smoking cessation, and substance abuse treatment are just a few of the interventions typically considered in this manner. In the analysis, success or failure is a latent variable; underneath and hidden by this dichotomy is a series of behavior changes. With the development of the stages of change model [1–3], it is now common for researchers to trace the effects of interventions on stages of behavioral change. Clinicians are also beginning to use this framework [4], but to date, there has been little consideration about whether this information can and should be used in cost-effectiveness analysis (CEA).

This paper reviews CEA methods and highlights a concern specific to behavioral interventions: the value of partial behavior change. We define partial behavior change as moving someone towards changing his/her behavior, without reaching success at the end of the study. Partial behavior change should be included in the CEA, and this can be

achieved using the stages of change model. Although this paper focuses on stages of change, the methods are robust and they could be easily modified to include other models of behavior change. For example, elsewhere, such as manufacturing, the concept of a “value chain” is often discussed. The value chain is a series of linked processes. Although the entire chain might represent a very complex objective (e.g., manufacturing a car), each link represents a straightforward task (e.g., installing a door). An intervention, such as computer automation, designed to make a better car, might have different effects for different links in the chain. At times it might be important to look at the overall effect of the intervention, but there also may be instances where it is more appropriate or more interesting to look at value added for specific links. In a sense, in this paper, we are focusing on a chain of health behaviors. At any point in this chain, value can be added. The question then focuses on the incremental costs and benefits of the value.

This paper is organized as follows. In the background section, we review CEA methods and the stages of change model. We then present a model for integrating the two. We then discuss how this model can accommodate two issues that frequently arise with behavioral interventions, namely, intermediate outcomes and subsample analysis. Throughout this paper, we use mammography and smoking cessation as examples, but the methods generalize to other topics. We also provide a specific example before we conclude.

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Background

Review of cost-effectiveness analysis

Cost-effectiveness analysis is increasingly considered an essential component for evaluating medical technology [5]. Although cost–benefit analysis remains widely used, especially outside of health, CEA remains the preferred method for valuing medical interventions [6]. In CEA, interventions are valued in comparison to alternatives by estimating an incremental cost–effectiveness ratio (C/E ratio), which is the ratio of the incremental cost of the intervention to the incremental health effect from the intervention (see Eq. (1)).

To date, the quality adjusted life year (QALY) model is the preferred metric for

$$\text{Incremental C/E Ratio} = \frac{C_1 - C_0}{E_1 - E_0} \quad (1)$$

estimating the health effects (E_1 and E_0) [6]. QALYs incorporate both duration of life and quality of life, such that each life year gained is multiplied by a quality weight reflecting the individual's quality of life in the health state for that year. Utilities, measured on a scale from 0 (death) to 1 (perfect health), can be used as the quality weights for given health states [7].

QALYs take into account preferences for different health states and the amount of time people spend in different health states for the remainder of their lives. Therefore, QALYs reflect a person's lifetime health path. Interventions may result in changes in lifetime health paths. By aggregating QALYs for people in the intervention and control groups, one can develop an estimate of the incremental health effect associated with the intervention. This provides the denominator for the C/E ratio.

With relative ease, this technique generalizes to more than two comparisons [8]. Other refinements can also be made, such as considering finer time gradations or states worse than death [6,9].

For behavioral interventions, this framework and Eq. (1) hold. However, evaluators of behavioral interventions need to be careful because the health effects observed during the study may not be complete. An intervention may have caused some people to think about and perhaps to plan for changing their behavior (e.g., to stop smoking). However, unless the person adopts this new behavior before the end of the study, then he/she may be incorrectly treated as a “failure,” rather than a possible success. For example, if an intervention caused a woman to quit smoking, but this happened after the study ended, then the intervention had some benefit. This benefit, which can be thought of as “partial behavior change,” should be included in the CEA. The stages of change model, which we introduce next, provides a way to measure partial behavior change.

Table 1

Example stages of change questions for smoking cessation

Are you currently a smoker?
No, I have never smoked (NONSMOKER)
No, I quit more than 6 months ago (MAINTENANCE STAGE)
No, I quit within the last 6 months (ACTION STAGE)
Yes, I currently smoke
(For smokers only) In the last year, how many times have you quit smoking for at least 24 h?
(For smokers only) Are you seriously thinking of quitting smoking?
Yes, within the next 30 days (PREPARATION STAGE if they have one 24-h quit attempt in the past year—refer to previous question . . . if no quit attempt then CONTEMPLATION STAGE)
Yes, within the next 6 months (CONTEMPLATION STAGE)
No, not thinking of quitting (PRECONTEMPLATION STAGE)

Source: <http://www.uri.edu/research/cprc/Measures/Smoking11.htm>, which references DiClemente et al. [25] and Velicer et al. [26].

Review of stages of change

The Transtheoretical Model, hereafter referred to as “stages of change,” was pioneered by Prochaska and DiClemente [1–3], and much of the early work was on substance use, problem behaviors, and smoking [2,10,11]. The stages of change model has become widely used in other behavioral interventions, such as cancer screening [12,13]. The model focuses on the temporal process of change behaviors and posits that people progress through successive stages until the behavior has changed.

The first stage is *precontemplation*, where persons do not recognize their problematic behaviors or they have no serious intention to change their behavior in the next 6 months. In the cancer literature, precontemplators would be women who have no intention to get a mammography in the next 6 months. People who are considering changing their behavior in the next 6 months have entered the stage of *contemplation*. From *contemplation*, the next stage is *preparation*, which is defined as having a plan of action in the next 30 days and a recent attempt to change their behavior. If the person changes their behavior, they are in the *action* stage. Adherence to the new behavior over time is indicative of *maintenance*. Not always do the individuals stay in the highest stage, and the model allows for cycling. People can move from maintenance to precontemplation. For example, in smoking cessation, this could be used to characterize individuals who currently smoke after periods of abstinence.

Stage of change can be measured by asking respondents a series of survey question. Table 1 shows example stage of change questions that have been used in smoking cessation research.

A model for integrating stages of change in a CEA

The goal of most behavioral interventions is to achieve action, and maintenance of the new, healthy behavior. Whether action or maintenance is observed depends on the intervention and on the study's duration. When action

or maintenance is not observed, the intervention may still have resulted in partial behavior change. Partial behavior change is defined as moving someone into successive stages of change, such as from precontemplation to contemplation, without reaching action. All behavioral interventions can yield some partial behavior change, but shorter studies are particularly prone to this because changing behaviors is time dependent. Consequently, analysts conducting a CEA with a behavioral intervention should not focus solely on people who successfully changed their behavior, but they also need to measure partial behavior change. As was discussed above, this is relatively easy to do. Interventions that collect stage-of-change data can measure partial behavior change and then incorporate this information into the CEA.

Including partial behavior change in a decision theoretic model has not typically been done. Implicitly, many analysts take a “conservative” approach and disregard partial behavior change. However, partial behavior change is not the same as no behavior change. If the intervention caused to progress in stage of change (e.g., precontemplation to contemplation), then this effect needs to be included in the CEA. Some of those who partially changed their behavior may change their behavior in the future. Therefore, failing to include partial behavior change in the CEA can bias the results.

The inclusion of partial behavior change is particularly important when a behavioral intervention is compared to a surgical intervention. Such comparisons are possible for some chronic conditions, such as urinary incontinence and obesity, where surgical and behavioral treatments co-exist. Behavior change is a time-dependent cognitive process; surgery is not. If a study randomized people to a behavioral or surgical intervention and followed people for 12 months, there can be partial behavior change in the behavioral arm, but not in the surgical arm. In this case, disregarding partial behavior change will bias the CEA towards surgery.

Including partial behavior change in a CEA requires information about the probability of moving from partial to successful behavior change. In essence, we are interested in estimating how many people in the intervention group will change after the intervention ends and without further intervention. By definition, this information is not observable in the intervention group. One source for these transition probabilities is the literature [14]. Alternatively, controlled studies can use the control group to estimate these probabilities. The control group provides the percentage of individuals who naturally progress in stage of change. Therefore, by analyzing the control group, the percentage that moved from precontemplation to contemplation in a given period of time can be estimated. For example, assume an intervention moved 40% of the people from precontemplation to contemplation in a year. If 10% of the contemplators in the control arm moved from contemplation to maintenance in one year, we might use 10% of the 40% as a reasonable estimate of the proportion who will change their behavior in the next year under the control

conditions. Hence, the study’s control group has the information necessary to forecast the number of people in the intervention arm who will eventually move from contemplation to maintenance without further intervention.

Irrespective of whether one uses published transition probabilities or data from the control group, an implicit assumption is that behavior changes after the study ends occur at the same frequency and rate as the general population. No research has found that behavioral interventions adversely affect later stage transitions. Thus, there is reason to believe that using the control group may produce conservative estimates; the probability of future behavior change could be higher depending on the intervention’s effect. Ongoing research on the stages of change model, especially research on the value of matched intervention [15–19], will provide evidence with which we can revisit this assumption in the future.

One of the key benefits of the stages of change model, at least from the perspective of a CEA analyst, is the ability to observe partial behavior change (e.g., precontemplation to contemplation) and then make an educated guess about who will reach action and maintenance after the study. Because few, if any, studies follow participants for life and because CEA involves comparing lifetime costs and lifetime benefits, the ability to value partial behavior change may be critical to the CEA.

Intermediate outcomes and subsample analysis

In the prior section, we discussed a model for integrating stages of change into a CEA. Frequently behavioral interventions use intermediate outcomes and analysts want to conduct subsample analyses. In this section, we discuss how the model can accommodate these two issues.

Intermediate outcomes

The standard text *Cost-Effectiveness in Health and Medicine* [6] recommends using QALYs as the effectiveness measure in the CEA. However, the panel also notes that analysts can use intermediate outcome measures. An intermediate outcome is, for example, smoking cessation at 60 days or receipt of a mammogram in the last year. Intermediate outcomes are particularly attractive for behavioral interventions because these studies would have to be either much longer or much larger to measure the impact directly on mortality or QALYs.

When intermediate outcomes are used in a cost-effectiveness analysis, the analyst must translate the intermediate outcome into QALYs. Intermediate outcomes vary in their ability to predict QALYs. And while a handful of intermediate outcomes predominate in most situations, there are theoretically an infinite number of intermediate outcomes. Accordingly, it is important for analysts to use the intermediate outcome with the best predictive power among those

that are commonly used. This maximizes the ability to translate intermediate outcome into QALYs.

Analysts conducting a CEA with intermediate outcomes still need to be concerned with partial behavior change. Unfortunately, there is not an easy way to integrate this information into the model. In this case, it may be very difficult to compare CEAs for studies that only report the intermediate outcomes. *Cost-Effectiveness in Health and Medicine* makes note of this and says that intermediate outcomes “may not capture all important aspects of the outcome of interventions and that they limit the types of interventions that can be compared across CEAs (p. 290) [6]”.

The key to comparability is the intermediate outcome’s operational definition. C/E ratios from different studies that attempted to increase mammography screening may not be comparable if one study used receipt of mammography in the past year and the other used receipt of mammography in the past 2 years. They differ because incomplete behavior change is more likely in the study with the shorter time period, all else being equal. Unless the studies translate the intermediate outcomes to a standard outcome, namely QALYs, the two studies cannot be directly compared.

Subsample C/E ratios

Generating C/E ratios for subsamples can be very useful for two reasons. First, studies often tailor the intervention to the participant’s stage of change. These are known as stage-matched interventions. This has been done in smoking and mammography, as well as other areas [13,20]. By their very nature, stage-matched interventions differ at each stage of change. In these interventions, analyzing an overall C/E ratio may be difficult or meaningless. The overall C/E ratio provides information on whether a stage-matched treatment strategy is cost-effective compared to an alternative. Alternatively, generating C/E ratios for subsamples, identified by the baseline stage of change, may provide more useful and interpretable information.

Second, in interventions that do not use stage-matched designs, subsample analyses may be important to determine if the intervention had differential effects based on baseline stage of change. There have been interventions where the overall effect was neither large nor statistically significant, but the intervention did show important effects for people at different baseline stages of change [21]. Thus, calculating only an overall C/E ratio for a study may mask important subsample effects. A recent study by Fishman et al. [22] found that the cost-effectiveness of an intervention to improve mammography was more favorable for people who had a prior mammography compared to those who did not. Fishman et al. [22] found that 36.1%, 52.6%, and 50.3% of women receiving the reminder postcard, reminder call, and motivational call, respectively, received a mammography. The data suggest that the reminder call and motivational calls were the most effective, but in fact,

Fishman et al. [22] find in a sub-sample analysis that women who had a previous mammography (i.e., women in relapse), had much higher rates of mammography than women without a previous mammography (i.e., precontemplation and contemplation).

Analysts could generate a total C/E ratio for the entire intervention; however, heterogeneity related to stage of change may make the overall C/E ratio difficult or impossible to interpret because it would be dependent on the proportions of individuals who were in each stage of change at baseline. Alternatively, one could model the separate stages of change with their separate costs and separate health effects. This is the equivalent to conducting subsample analyses. These subsample C/E ratios might be easier to interpret, in part because they show how the C/E ratio is affected by the composition of the sample. Managers and clinicians can then use this information for planning and programmatic decisions.

The discussion about stages of change, developing staged-matched interventions, and including stage of change in the CEA raises questions about study design. If a researcher designs a study where the primary analysis will focus on subsamples, then one should power the study for the subsamples and perhaps stratify recruitment by stage of change. The trial would then be powered to provide answers at this level. If the study is only powered for the overall effect, and one hopes to assess whether there are differences in stage of change, one would need to have a larger effect size or the investigator would not have enough power. A very large literature on clinical trial design exists to provide guidance on this [23,24].

Example

This section introduces a hypothetical example to describe how CEAs would benefit from including information on stage of change. Let us assume that a health plan had a population of women ages 50–65 who have not had a recent mammography, and that the health plan had a choice between three different cancer-screening strategies. The three strategies included a simple mailed reminder postcard, a reminder phone call, and a personalized motivational phone call. The health plan designed a randomized controlled trial and enrolled 2,700 women, 900 into each of the three arms of the trial. The unit costs for the simple mailed reminder postcard, reminder phone call, and personalized motivational phone were US\$3.50, US\$19.00, and US\$24.00, respectively. The percentage of women who achieved action and received a mammography by the end of the study was 23.6%, 34.2%, and 33.0% for the three strategies.

Estimating incremental cost-effectiveness ratios is straightforward. The reminder phone call is US\$15.50 more expensive and 10.6% more effective than the reminder postcard. Thus, the incremental cost-effectiveness ratio is

Table 2
Incremental cost-effectiveness ratios without partial behavior change

	Incremental cost (US\$)	Incremental effectiveness (%)	Incremental CER (US\$)
Overall results			
Reminder call vs. postcard	15.50	10.6	146.84
Motivational call vs. postcard	20.50	9.3	219.64
Reminder call vs. motivational call	− 5.00	1.2	− 409.09 ^a

Data are from a hypothetical example.

^a A negative number indicates that the reminder call was less expensive and more effective (also known as dominant).

US\$146.84 (Table 2). The reminder phone call was also more effective and less expensive than the motivational phone call; accordingly, the reminder phone call is said to dominate the motivational phone call. The decision maker would then have to weigh the relative cost and effects of the reminder postcard and the reminder phone call.

The problem with the cost-effectiveness ratio calculated above is that it does not include partial behavior change. Table 3 shows that the three strategies differed in their effect on partial behavior change. Some of the people who

Table 3
Transition of participants based on their stage of change

	Postcard		Reminder call		Motivational call	
	N	%	N	%	N	%
<i>Began in precontemplation</i>						
Follow-up stage of change						
Precontemplation	190	63.3	155	51.7	139	46.3
Contemplation	75	25.0	87	29.0	50	16.7
Preparation	21	7.0	40	13.3	64	21.3
Action	14	4.7	18	6.0	47	15.7
<i>Began in contemplation</i>						
Follow-up stage of change						
Precontemplation	0	0.0	0	0.0	0	0.0
Contemplation	190	63.3	128	42.7	136	45.3
Preparation	21	7.0	40	13.3	64	21.3
Action	89	29.7	132	44.0	100	33.3
<i>Began in preparation</i>						
Follow-up stage of change						
Precontemplation	0	0.0	0	0.0	0	0.0
Contemplation	0	0.0	0	0.0	0	0.0
Preparation	190	63.3	142	47.3	150	50.0
Action	110	36.7	158	52.7	150	50.0
Action at follow-up ^a	213	23.7	308	34.2	297	33.0
Estimated action including partial behavior change ^b	323	35.9	411	45.6	420	46.7

Data are from a hypothetical example.

^a Action at follow-up indicates that the participant reported getting a mammography at follow-up.

^b Estimated action is based on those who reached action at end of study and then those people estimated to change behavior after the study ends. We assumed that 1%, 6%, and 40% of women in precontemplation, contemplation, and preparation, respectively, would get a mammography after the study.

partially changed their behavior will get a mammography after the study and this information should be included in the cost-effectiveness. For this example, we assumed that 1%, 6%, and 40% of women in precontemplation, contemplation, and preparation, respectively, would get a mammography after the study. After including partial behavior change, the personalized motivational call is no longer dominated and is the most effective (and most expensive) option (Table 3).

When we included the partial behavior change in our example, we did not specify exactly when after the study the partial behavior change progressed into action. The day after the study ended these women could have achieved action, or it could be many years in the future. Earlier in the paper we indicated that researchers could use transition probabilities from the literature or data from the control group to estimate the percentage that would get mammograms in the future. To include the partial behavior change in the analysis, it is important to have a specific time period and future benefits should be discounted to a present value [6].

Once the partial behavior change is included, it is possible to conduct a subsample analysis. The subsample incremental cost-effectiveness ratios are presented in Table 4; these include partial behavior change and are presented by baseline stage of change. Including information on stage of change provides new and potentially useful information. The data show that no single strategy is always preferred. Integrating the stage of change model identifies the situations where the strategies are more cost-effective than the alternatives. For example, for people in contemplation or preparation, the reminder phone call dominates the motivational phone call. However, the motivational phone call is more effective than the reminder phone call for women in precontemplation. Therefore, health plans could use different

Table 4
Subsample analysis with partial behavior change

	Incremental cost (US\$)	Incremental effectiveness (%)	Incremental CER (US\$) ^a
<i>Reminder call vs. postcard</i>			
Baseline stage of change			
Precontemplation	15.50	4.0	383.98
Contemplation	15.50	15.6	99.16
Preparation	15.50	9.6	161.46
<i>Motivational call vs. postcard</i>			
Baseline stage of change			
Precontemplation	20.50	16.1	127.08
Contemplation	20.50	8.3	246.39
Preparation	20.50	8.0	256.25
<i>Motivational call vs. reminder call</i>			
Baseline stage of change			
Precontemplation	5.00	4.0	123.86
Contemplation	5.00	− 7.3	− 68.39
Preparation	5.00	− 1.6	− 312.50

Data are from a hypothetical example.

^a A negative number indicates that the reminder call was less expensive and more effective (also known as dominant).

strategies depending the target members and their stages of change.

Receipt of mammography in this example is an intermediate outcome. If the decision maker is only concerned about a choice of mammography screening strategies, then modeling how these strategies affect QALYs may not be necessary. But, as mentioned earlier, there may be times when extending the analysis to consider the incremental cost per QALY may be worthwhile or even critical.

Conclusions

Behavioral interventions incur costs today to avoid future morbidity and mortality. Although behavioral interventions often use the adoption of a new healthy behavior as the main outcome, the process of changing is complex and lengthy. Increasingly, researchers are using the stages of change model to gain insight on how interventions affect and interact with the process of change. To date, however, this information has not been used in cost-effectiveness analysis.

We focused on using stages of change to measure the behavior change process. However, stages of change is but one of many methods for making such estimates. As an analogy, we introduced the concept of a value chain and suggested that these methods would hold even if we did not use the stages of change model. Talking about a value chain also allows us to focus on the broader question—how to best conduct a CEA with a behavioral intervention—and helps avoid getting mired in some of the debates about stages of change, such as what is the best way to measure precontemplation. Not to suggest that those debates do not have their merits, but the issues and methods that we raise would hold if there were modifications in how one measures or defines stages of change. In addition, such subtleties could be handled in a CEA sensitivity analysis, if appropriate.

We discussed a straightforward approach to include stages of change information in a cost-effectiveness analysis. This involves accounting for partial behavior change, which is defined as someone who progressed in stage of change but did not successfully change his/her behavior at the end of the study. Some people who partially change their behavior may eventually successfully change their behavior. With modeling, these benefits can be captured in the cost-effectiveness analysis.

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