CHAPTER

8

COST-EFFECTIVENESS OF CLINICS

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This chapter demonstrates the application of decision trees to the analyses of the cost-effectiveness of clinics. Healthcare managers often start clinics and programs. They need to understand how much to charge for the services offered through their new investment. They need to justify the effectiveness of clinics to various funding agencies. They need to identify weak and money-losing operations and work on improving them. Unfortunately, the cost-effectiveness of clinics is not always clear because it is difficult to distinguish program costs from other expenditures in the organization. Many clinicians have multiple roles within the organization, and it is not clear how much of their time and effort are going into the new program versus other activities within the organization. It is difficult to understand how management personnel and other indirect costs affect the viability of the new clinic. To make things more confusing, new clinics share facilities with existing programs, making it difficult to charge them rent or allocate a portion of capital expenditures to these clinics. A rational approach would require one to isolate the cost of the program from other costs and to decide how much of the overhead should be carried by the program.

In addition, a program's cost is just part of the picture. Any program or clinic not only has its own services but also affects the services offered by other units. For example, offering a new program in cardiology might help identify patients for the existing home health care service of the organization. If the new clinic is more modern and advanced than existing operations (e.g., it uses electronic medical records or new surgical equipment), then it might change the image of the entire organization and affect the referral to all existing clinics. The new clinic might be the loss leader that attracts patients to other parts of the organization. In short, any new investment may have many consequences. If you are evaluating the cost-effectiveness of a new clinic, it is important to go beyond a program's operations and costs and look at its affect on other services too. This chapter shows how healthcare managers can isolate the cost of a clinic or program and trace the consequences of offering a service by using decision analytic tools.

Managers who have to justify the operations of a clinic to outside planning offices or insurance companies might be interested to look at the

This book has a companion web site that features narrated presentations, animated examples, PowerPoint slides, online tools, web links, additional readings, and examples of students' work. To access this chapter's learning tools, go to ache.org/DecisionAnalysis and select Chapter 8.

broad consequences of the clinic. Instead of just looking at how the clinic affects their existing services, they might want to look at the effect of the clinic on payers. They might not want to limit the analysis to specific internal components but also include utilization of services outside the organization. This chapter will show how such a broad analysis of the consequences of opening a clinic can be carried out.

These ideas will be demonstrated by an example that applies them to an evaluation of the cost-effectiveness of locating a substance abuse treatment clinic within a probation agency (Alemi et al. 2006). More than four million adults are on probation or parole supervision. Supervision failures, often linked to a return to drug use, create a cycle back into prison and jail. If supervision can be enhanced with treatment, then perhaps the cycle can be broken and offenders can return to the community, not only restoring their lives but also perhaps saving money associated with crime and multiple returns to prison. In recent years, a number of studies have examined the cost-effectiveness of substance abuse treatment (Shepard and Reif 2004; Kunz, French, and Bazargan-Hejazi 2004; Kedia and Perry 2003; Kaskutas, Witbrodt, and French 2004; Jofre-Bonet et al. 2004; French et al. 2002; Doran et al. 2004; Dismuke et al. 2004; Dennis et al. 2004; Daley et al. 2004; Caulkins et al. 2004; Berger 2002) and ways to reduce recidivism (McCollister et al. 2004, 2003; Logan et al. 2004; Fass and Pi 2002; Aos 2002, 2003; Aos and Barnoski 2003; Aos et al. 2001, 2004). For ease of reference, the model of coordinating the clinic with the probation agency is referred to as "seamless probation" and is compared to the traditional model of providing probation and substance abuse treatment services independently.

Perspective

In any analysis, the perspective of the analysis dictates whose costs are included. If one is analyzing cost to the patient, then cost to the hospital is not included. If one is analyzing cost to the organization only, then cost to external agencies are not included. A societal perspective may include costs incurred to caregivers and other social components of care. If the analysis is done for payers, then costs to these organizations are included, and other costs are ignored.

In the seamless probation study, the focus of the analysis was costs and benefits to the government agencies that were expected to fund the clinic.

Time Frame

Many of the benefits of new procedures may occur several years later (e.g., reduced hospitalizations), while the cost may occur during the clinic visits. It is therefore important to precisely define the time frame for the cost-benefit analysis and to discount future returns to current values. For example, the benefit of seamless probation is observed years later in the form of reduced crime. To capture these future outcomes, a sufficiently long perspective is needed. The study on seamless probation examined the effect of the substance abuse clinic for two to three years after enrollment in the study. This was long enough to see the effect of short-term events but not long enough to capture lifetime events.

Steps in the Analysis

The analysis of the cost-effectiveness of a clinic requires the estimation of a number of related concepts, including the following:

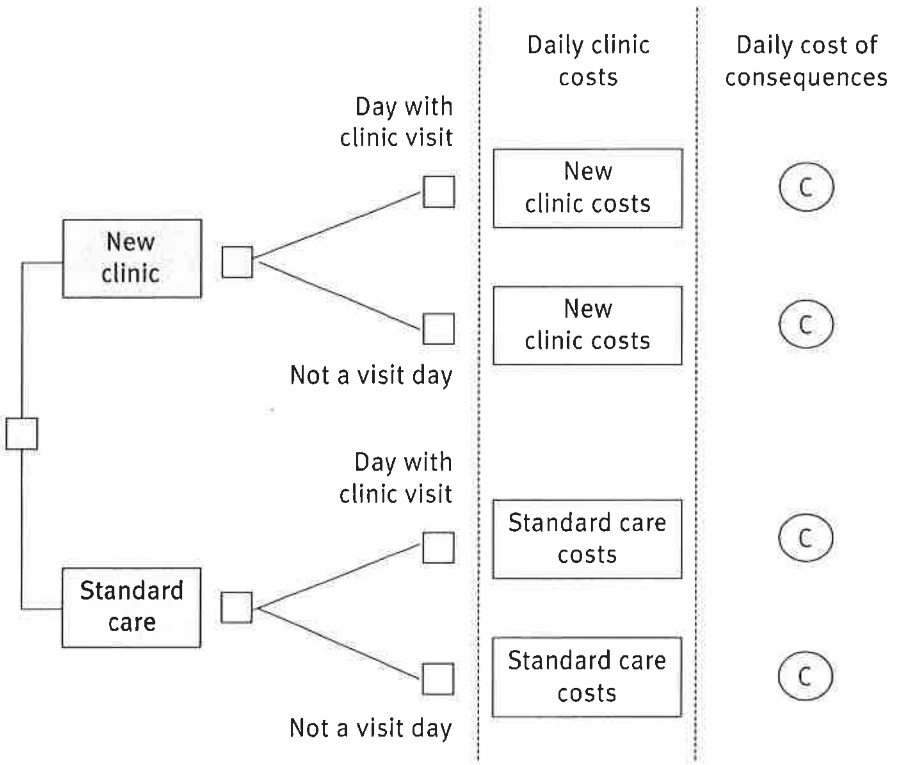
1. Create a decision analytic model that includes clinic utilization, clinic operating costs, and the effect of the clinic on other costs.
2. Estimate probabilities of daily clinic utilization and various consequences.
3. Estimate the daily cost of the clinic's operation from the clinic's budget.
4. Estimate the daily cost of various consequences from the literature.
5. Calculate the expected cost of the clinic.
6. Conduct a sensitivity analysis.

Each of these steps is further explained in the remainder of this chapter.

Step 1: Create a Decision Analytic Model

Decision models have been used to model costs and benefits of a wide array of services (Varghese, Peterman, and Holtgrave 1999; Marley 1990; Davis 1989; McNeil 2000; Carlos et al. 2001; Palmer et al. 2002; Post, Kievit, and Van Bockel 2004; Kocher and Henley 2003; Inadomi 2004; Sonnenberg 2004; You et al. 2004; Targownik et al. 2004; Culligan et al. 2005; Lejeune et al. 2005; Jordan et al. 1991; Malow, West, and Sutker 1989). The

FIGURE 8.1
A Decision Trees for Evaluating Cost-Effectiveness in New Clinics



typical analysis, as shown in Figure 8.1, starts with a decision node that contrasts joining the new clinic against the standard care alternative. Then, the various events within the program are indicated (e.g., visits). Because the analysis is done per day, these events are shown as days in which a visit has occurred. Next, two costs are reported: the daily cost of the clinic and the daily cost of the clinic's consequences. The daily cost of the clinic includes the personnel, material, information system, building, and other capital and operating costs of delivering the program. The cost of the clinic's consequences is itself a separate decision tree. In Figure 8.1, cost of the consequences is shown as node "C." This node is broken into a more detailed decision tree in Figure 8.2, which shows the daily probability of various consequences and the daily cost associated with each.

Note that, in the analysis, all probabilities and costs are calculated per day. Thus, cost is discussed in terms of the daily probability of initiating treatment and the daily probability of retaining a client. Consequences are discussed in terms of the daily probability of needing a service and the daily cost of various services. In this fashion, a consistent unit of analysis is kept throughout the analysis.

Figure 8.2 assumes that the patient may have a day of hospitalization or a day in which a clinic visit occurs. In addition, the figure has a

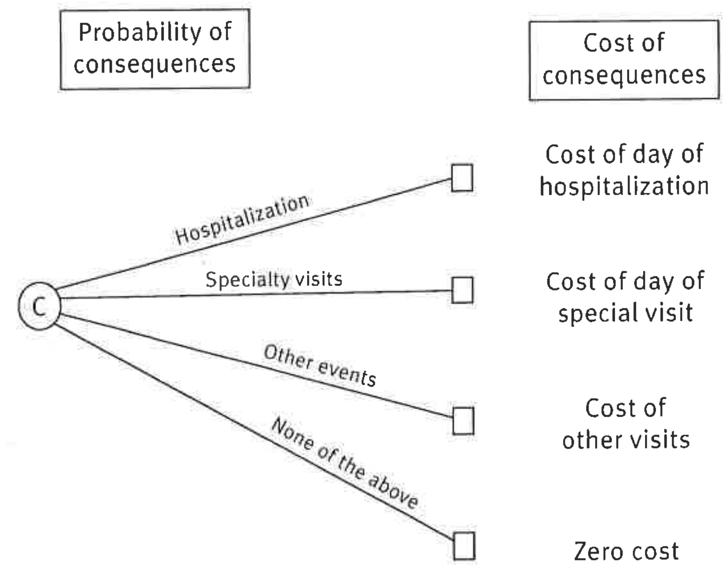


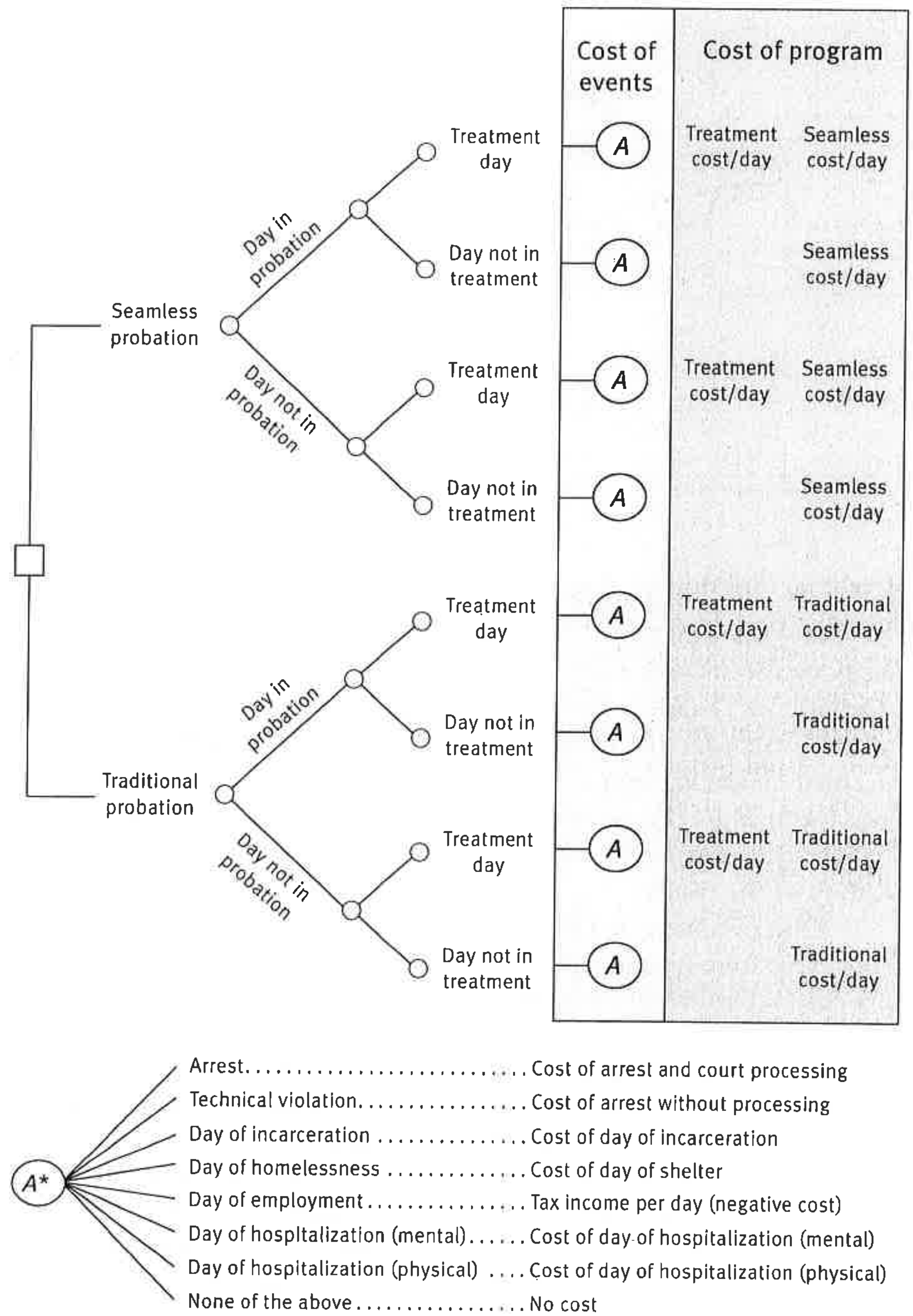
FIGURE 8.2 An Example of a Decision Tree for Costs of Consequences

placeholder for other major events that might occur as a consequence of the clinic visit. Finally, to make the list of possible events complete, one needs to also include the situation in which none of the major events imagined will happen. Strictly speaking, the events depicted must be mutually exclusive and exhaustive. Some events—for example, visiting a specialist and being hospitalized—may occur on the same day and thus may not be mutually exclusive. If this is not occurring often, the analysis depicted in Figure 8.2 may continue as is and be considered an approximation of the reality.

One advantage of a decision tree is that it separates the probability of an event from its unit cost. For example, in Figure 8.2, the probability of a day of hospitalization is separated from the cost of a day of hospitalization. Unit costs of services are unlikely to change under different alternatives. Therefore, the analyst does not need to estimate the unit cost for each alternative. For example, although the new clinic is expected to affect the probabilities of hospitalization, it is not expected to affect the unit cost of a day of hospital care. Because the unit cost is the same under each alternative, changes to the unit cost are unlikely to affect the analysis in significant ways. Therefore, the analyst can use national estimates for unit costs and does not need to collect data to assess these costs within the organization. Decision analysis makes data collection easier and perhaps more accurate by reducing the number of estimates needed and by using national estimates for components that do not change under various alternatives.

Figure 8.3 shows the overall structure of the analysis for seamless and traditional probation. The left section of the decision tree depicts the decision. Immediately after this node, the probability of receiving one day

FIGURE 8.3 Decision Tree for Seamless and Traditional Probation



*Assuming negligible overlap among these events on same day of probation or one day of treatment is shown. These branches indicate the utilization of services. The middle section of the decision tree depicts treatment and probation outcomes—previously referred to as the consequences of clinic visits. Next, the decision tree assumes that the probabilities for a day of homelessness, a day of unemployment, a day of foster care for children, a day of hospitalization, and a day in prison will vary with client's probation and treatment status. The right section of the decision tree depicts the cost associated with each path in the tree, measured per client per day.

Step 2: Estimate Probabilities

This section discusses how the probabilities needed for the analysis are calculated. There are four ways to assess these probabilities, as shown in see Table 8.1.

The first method is to monitor a large cohort of patients (preferably randomly assigned to various alternative arrangements) over time and count the frequency of the events. This method is objective and requires considerable follow-up time and access to a large number of patients. For example, one might follow up 100 patients in the clinic and report the frequency with which they are hospitalized.

The second method is to examine the time between reoccurrences of events in the decision tree. If you can assume that the daily probability of the event has a binomial distribution, then the time between the occurrences of the event has a geometric distribution, and the daily probability can be calculated by number of days in between the reoccurrence:

$$\text{Daily probability of event} = \frac{1}{1 + \text{Number of days to reoccurrence of the event}}.$$

TABLE 8.1
Four Ways of Assessing Probabilities

	Time to Event	*Frequency Counts*
Objective	Number of days to event is measured and transferred by formula to daily probabilities of the event.	A large cohort of patients is followed up and frequencies of various events are calculated.
Subjective	Experts are asked to estimate the number of days to the event, and daily probabilities are calculated from these estimates.	Experts are asked to estimate the frequency of events.

This method is objective but requires a shorter follow-up time than the first method, especially if the probabilities being assessed are relatively small. For example, the daily probability of hospitalization might be calculated as the number of days before the patient is hospitalized. If a patient is hospitalized after 80 days, then the daily probability of hospitalization is 1/81.

The third and fourth methods are the same as the first two but are based on experts' opinions rather than objective data. You might ask experts about days to the event or the frequency of the event. You might ask a clinician to estimate how many days before a patient is hospitalized; or you might ask an expert about the patient's prognosis by asking him to specify the likelihood that the patient might be hospitalized within 30 days.

In the seamless probation example, the first method was used. The researchers recruited 272 offenders with extensive criminal justice histories and randomly assigned them to seamless and traditional probation. Offenders were interviewed at baseline and at three 12-month follow-up periods to examine their utilization of various services. Of the clients, 78 percent of those on traditional probation and 77 percent of those in the seamless group were available for follow-up interviews.

When assessing objective frequencies, it is important to keep in mind that the decision tree requires the calculation of the daily probability of various events. These probabilities are calculated by dividing the length of time that an event occurs (e.g., days of hospitalization) by the total number of follow-up days. When calculated in this fashion, the probability of one day of an event is affected by the duration of the event. For example, the client's length of stay in treatment alters the probability of a day of treatment. The longer the treatment program, the larger the daily probability. A client who is in treatment for one year will have a daily probability of 1 percent. A client in treatment for one month in a year will have a daily probability of 8 percent. As clients stop and restart treatment, the daily probability changes. The proposed method of calculating the probability of the event takes into account multiple returns to treatment. Table 8.2 provides the average length of various events for the clients who were followed up in the study, and Table 8.3 turns these durations into daily probabilities.

Table 8.2 shows that the clients in the seamless group had more treatment, more probation time, and lower arrest rates but also more technical violations (instances in which a probation officer jails the client while he is waiting to appear in front of the judge). The clients in the seamless group also spent more days in prison/jail—despite the fact that they were arrested less often—in part because they had more technical violations.

TABLE 8.2 Average Duration of Various Events per Client

	Traditional		*Seamless*	
	Average for 100 Clients	*Standard Deviation*	*Average for 101 Clients*	*Standard Deviation*
Follow-up days	1,001.20	308.60	1,006.21	339.03
Treatment days	114.78	212.21	200.00	215.00
Probation days	410.12	195.54	456.81	213.52
Arrests in first year	1.00	1.40	0.86	1.09
Technical violation of probation	0.35	0.48	0.40	0.49
Days in prison	112.15	193.46	140.23	213.38
Days employed	378.65	390.59	391.32	439.38
Days in hospital (mental illness)	0.30	1.49	1.65	12.31
Days in hospital (physical illness)	0.25	1.70	0.12	1.19
Days in homeless shelter	1.22	8.96	6.51	40.44

SOURCE: Alemi et al. (2006). Used with permission.

Table 8.3 shows the probability of events in each pathway of the decision tree in Figure 8.3. The probability of each consequence for each pathway in the decision tree is calculated by dividing the duration of the events (e.g., length of stay) observed for patients in the pathway by the number of days these patients were followed up. With the exception of arrest and technical violations, these probabilities reflect both the incidence of the event and the duration of the event.

The decision tree in Figure 8.3 depicts eight pathways. By convention, the probabilities of events in a pathway are conditioned on the events preceding them. In the decision tree, treatment occurs after participation in probation; therefore, the analyst needs to show the conditional probability of treatment given probation. Conditional probabilities, as discussed in Chapter 3, are calculated by restricting the universe of possible events to the condition and then examining the joint frequency of the condition and the event. In this case, the conditional probability of probation and treatment is calculated by dividing the joint probability of these two events with the marginal probability of being in probation. For example, using Table 8.4, the conditional probability of clients in seamless probation seeking treatment while they are in probation was $0.14 \div 0.45 = 0.31$. In contrast, the same conditional probability for clients who were in a traditional probation was $0.05 \div 0.41 = 0.12$.

TABLE 8.3

Conditional Probabilitiy of Consequences of Lack of Treatment and Probation

Conditions			*Probability of Event Given Probation and Treatment Conditions*							
Type of Probation	*Probation Day*	*Treatment Day*	*Technical Violation*	*Arrest**	*Hospital Day (Mental)*	*Hospital Day (Physical)*	*Day in Prison*	*Day Employed*	*Day Homeless*
Traditional	No	No	.0001	.0005	.0004	.0003	.1221	.4430	.0016
Traditional	No	Yes	.0010	.0007	.0000	.0000	.3725	.1250	.0000
Traditional	Yes	No	.0011	.0020	.0000	.0001	.0800	.3432	.0000
Traditional	Yes	Yes	.0003	.0005	.0000	.0000	.0990	.1663	.0000
Seamless	No	No	.0001	.0001	.0036	.0002	.1850	.4631	.0061
Seamless	No	Yes	.0000	.0000	.0599	.0000	.3069	.2873	.0208
Seamless	Yes	No	.0011	.0016	.0073	.0000	.1029	.2629	.0005
Seamless	Yes	Yes	.0034	.0012	.0296	.0000	.0898	.2787	.0147
Total for traditional probation			.0003	.0027	.0003	.0002	.1075	.3993	.0009
Total for seamless probation			.0004	.0024	.0021	.0001	.1405	.3824	.0075

* Probability of arrest was calculated for 1 year; all other rates were calculated for 2.75 years.

SOURCE: Alemi et al. (2006). Used with permission.

TABLE 8.4 Probability of Successfully Completing a Day of Probation and Treatment

	Traditional Clients (n = 100)			*Seamless Clients (n =101)*		
	Not a Probation Day	*Probation Day*	*Total*	*Not a Probation Day*	*Probation Day*	*Total*
Not a treatment day	0.53	0.36	0.89	0.48	0.32	0.80
Treatment day	0.06	0.05	0.11	0.06	0.14	0.20
Total	0.59	0.41	1.00	0.55	0.45	1.00

SOURCE: Alemi et al. (2006) Used with permission.

Step 3: Estimate the Daily Cost of the Clinic

The daily cost of a clinic or program is calculated by dividing the total cost of a program (including operating and fixed costs) by the number of days clients were enrolled in the program during the previous year (program census). Total program costs are estimated from the organization's budget. Typically, the budget provides cost of personnel, supplies, equipment, buildings, and information services.

Not everything shows in the organization's budget, however. To the costs available in budgets, one adds the market value of buildings, volunteer services, and unaccounted retirement costs. Economic cost of a clinic differs from accounting cost because it includes the value of assets or personal services donated to the program. For example, accounting procedures usually depreciate building costs. This distorts the real market value of the asset. To correct for these inaccuracies within the budget, whenever possible the analysis should rely on the lease value of major assets such as buildings, office space, or information technology.

When a picture of true economic costs is established, the costs are allocated to various programs within the organization. Sometimes these allocations are clear, as when the budget of the clinic is separate from that of other operations. At other times, costs of various programs and clinics are mixed together in the same budget and an allocation scheme must be decided upon. Table 8.5 provides an allocation scheme for various component of the budget.

The costs of many budget categories are allocated to the program using the activity of employees by the following formula:

$$C_{p,c} = \frac{(C_{b,c} + C_{m,c})\, E_p}{E_b},$$

where

- $C_{p,c}$ is the program cost in budget category c;
- $C_{b,c}$ is the cost to the entire organization in budget category c, estimated from the budget;
- $C_{m,c}$ is the market value of donated services or unreported capital resources in budget category c;
- E_p is the number of full-time equivalent personnel working in the program; and
- E_b is the number of full-time equivalent personnel working in the entire organization.

The key for allocating the organization's budget to program costs is determining personnel activities. Clearly, some personnel will have dual roles, and it is important to ask them the percent of time they work on different activities. This is typically done by a survey of employee activities. Because of the focus on employee activities, the approach described above is often called *activity-based costing*.

In the seamless probation, two new operations were introduced: a new clinic for providing substance abuse treatment and a new way of doing probation. The study estimated the daily costs of both operations. The daily cost of providing the probation was calculated from the budget of the probation agency and the market value of items not in the budget. Building costs were based on the lease value of equivalent office space. The cost of information services provided by other state agencies, which were not directly on the budget of the probation agency, was added in. Table 8.6 shows the

TABLE 8.5 Allocation Schemes for Calculating Program Cost from Budget

Budget Category	*Allocation Scheme for Shared Items*
Clinical and support personnel	Distribution of personnel's time
Management personnel	Distribution of clinic and support personnel
Information services	Frequency of requests to the service
Equipment cost	Frequency of use and age of equipment
Building	Square footage based on patient census
Supplies	Personnel if supplies are used by employee; otherwise proportional to census if supplies are used by patients
Utilities and other overheads	Total cost of clinic and other operations (after above allocations)

TABLE 8.6
Cost of Probation per Day and per Client

	Costs (June 30, 2000 to July, 2001)			
	Agency Costs	Investigative Reporting*	Seamless Supervision*	Traditional Supervision*
Personnel services	$1,191,362	$163,182	$79,320	$948,859
Contractual services	$11,984	$1,641	$798	$9,544
Supplies and materials	$9,436	$1,293	$628	$7,516
Building rental	$206,144	$28,236	$13,725	$164,183
Equipment rentals+	$122,083	$16,722	$8,128	$97,233
Information services++	$148,621	$20,357	$9,895	$118,369
Economic cost of volunteers	$5,013	$687	$334	$3,993
Total	$1,694,643	$232,117	$112,828	$1,349,697
Cost per work day	$6,009	$823	$400	$4,786
Number of client days		15,792	9,588	206,424
Cost per day per client		$15	$12	$7

* Personnel, contractual, supplies, building, equipment, information services, and volunteer costs were allocated proportional to activities of probation officers involved in investigative reporting, seamless supervision, and traditional supervision.
\+ Estimated from market lease value.
++ Estimated from state and city operating budgets.

SOURCE: Alemi, F., F. Taxman, V. Doyon, M. Thanner, and H. Baghi. 2004. "Activity Based Costing of Probation With and Without Substance Abuse Treatment: A Case Study." *Journal of Mental Health Policy and Economics* 7 (2): 51–57. Used with permission.

total agency budget and allocation of these costs to various activities: investigative reporting, seamless supervision, and traditional supervision.

A similar procedure was followed for the cost of the substance abuse treatment clinic. Table 8.7 shows the total budget of the clinic and its allocation to three programs within the clinic. Like before, items that did not show in the budget of the clinic (e.g., centralized management costs) were added to the accounting costs.

Program Census

A key factor in estimating cost per day of service is estimating the number of days of enrollment, or *program census.* Errors in calculating program census could lead to surprising results. Very expensive programs may show a low daily cost if one overestimates the program's census. Likewise, inexpensive programs may have a high daily costs if the census is estimated to be too low. Given the importance of census in calculating daily costs, it is important to have an accurate estimate of this factor.

Note that the number of days clients are enrolled in the program is not the same as the number of visits. Clients stay in a service even when they do not visit the clinic. There are three methods for estimating enrollment days. First, if admission and discharge dates are available, enrollment can be measured from the difference. Sometimes these data are not readily available. In the second method, the clinicians can be asked to

TABLE 8.7
Cost of a Day of Treatment

Category	*Total*	*CROP Program*	*Outpatient Program*	*Methadone Program*
Personnel	$1,266,651	$64,425	$732,452	$469,774
Building lease value	$75,435	$5,372	$48,275	$21,788
Equipment lease value	$65,420	$2,456	$26,773	$36,191
Operations	$47,425	$1,259	$15,888	$30,278
Centralized management	$397,259	$15,814	$240,449	$140,996
Total costs	$1,852,189	$89,325	$1,063,836	$699,027
Enrollment days based on counselor's estimated panel size		$9,490	$89,790	$40,150
Enrollment days based on time between most recent discharge and admission dates		$11,043	$44,860	$57,945
Cost per enrollment day		$8.70	$15.80	$14.25

SOURCE: Alemi, F., and T. Sullivan. "A Example of Activity Based Costing of Treatment Programs Using Time Between Discharges." Working paper. Used with permission.

estimate their average panel size during the previous month. Then enrollment days are calculated as 365 days × the average panel size. The third method is to look at the time between the most recent discharge and the admission dates for the clinician. All three methods are subject to errors, because clinicians may overestimate their panel size, and historical discharge and admission dates may not reflect recent patterns. To make a more stable estimate, the enrollment days estimated from the various methods can be averaged. In addition, the range of the estimates can be used to guide the sensitivity analysis.

Table 8.7 shows the estimates of the enrollment days using different methods. The estimates vary a great deal. In two programs, the two estimates are close to each other, but for the outpatient program the two estimates are considerably different.

Step 4: Estimate the Cost of Consequences

Typically, the daily cost of consequences (e.g., day of hospitalization) does not change across alternatives. The clinic and the standard care alternative will differ in the frequency of occurrences of various consequences but not in the daily cost of each occurrence. Therefore, these daily costs can be estimated from national or regional values available through the literature.

For example, the decision tree in Figure 8.3 separates the probability of arrest from its cost. Because cost of arrest is unlikely to change with the use of the seamless probation program, national estimates were used for these costs. Table 8.8 shows the estimated cost of arrest and court processing using 2001 and 2004 values.

Table 8.9 shows the daily cost of various consequences as estimated from published national or regional data. The cost of a day of employment

TABLE 8.8
Cost of Arrest and Court Processing*

	Number of Cases in Millions	*Expenditure in 2001 in Millions*	*Cost per Case in 2001*	*Cost per Case Inflated to 2004 Prices*
Police arrests	13.7	$72,406	$5,285.11	$6,330.35
Adult judicial cases	92.8	$37,751	$406.80	$487.25

* Includes local, state, and federal costs.

SOURCE: Bauer, L., and S. D. Owens. 2004. "Justice Expenditure and Employment in the United States 2001." *Bureau of Justice Statistics Bulletin*, May.

TABLE 8.9 Cost per Occasion or per Day of a Consequence

	Technical Violation	*Arrest*	*Hospital Day (Mental)*	*Hospital Day (Physical)*	*Day in Prison*	*Day Employed*	*Day of Shelter*
Cost of consequences	$487	$6,818	$1,164	$1,868	$74	($1.50)	$30

was the exception to the rule. This cost was estimated by the tax paid by offenders on legal income they had during probation.

The cost of various consequences can be calculated by multiplying the daily probability of the consequence by its daily cost. Table 8.10 provides the expected cost for the eight pathways in the decision tree in Figure 8.3.

Step 5: Calculate the Expected Cost

As mentioned in Chapter 4, expected cost can be calculated by folding back a decision tree so that each node is replaced by its expected value, starting from the right side of the tree. Another way of calculating the expected cost, a method that is easily implemented within Excel, is to calculate the joint probability of events within each pathway and multiply this probability by the total costs incurred during the pathway. For example, in Figure 8.1 there are four pathways, each with a probability of occurring and corresponding program and consequence costs. The expected value of this decision tree can be calculated by first calculating the expected cost of consequences by multiplying the cost of each consequence by its probability and then summing across all consequences. Next, the expected cost for each pathway is calculated by multiplying the probability of the path by its total costs (sum of the program's cost and expected cost of consequences). The expected cost of each alternative is calculated by summing the expected cost of each pathway that emerges from the alternative.

The expected cost for seamless and traditional probation was calculated in the three steps. First, the expected cost of the consequence was calculated by multiplying its probability by its cost. This is shown in columns four through ten in Table 8.10. Next, the expected cost of each pathway was calculated. This was done by summing the expected cost of consequences (all rows in Table 8.10) and multiplying the total by the joint probability of events in the pathway. Finally, the expected cost of seamless probation was calculated by summing the costs of the pathways that followed from joining seamless probation (rows five through eight in Table

TABLE 8.10
Expected Cost in Different Decision Tree Paths

Condition			*Cost of Consequences*							*Cost of Programs*	
Type of Probation	*Probation Day*	*Treatment Day*	*Technical Violation*	*Arrest*	*Hospital Day (Mental Illness)*	*Hospital Day (Physical Illness)*	*Day in Prison*	*Day Employed*	*Day of Shelter*	*Cost of Probation*	*Cost of Treatment*
Traditional	No	No	0.03	3.27	0.45	0.58	9.04	(0.66)	0.05	$0	$0
Traditional	No	Yes	0.51	4.53	0.00	0.00	27.56	(0.19)	0.00	$0	$15.8
Traditional	Yes	No	0.54	13.70	0.05	0.18	5.92	(0.51)	0.00	$7	$0
Traditional	Yes	Yes	0.16	3.74	0.00	0.00	7.33	(0.25)	0.00	$7	$15.8
Seamless	No	No	0.04	0.64	4.20	0.33	13.69	(0.69)	0.18	$0	$0
Seamless	No	Yes	0.00	0.00	69.77	0.00	22.71	(0.43)	0.63	$0	$15.8
Seamless	Yes	No	0.56	10.96	8.50	0.00	7.61	(0.39)	0.01	$12	$0
Seamless	Yes	Yes	1.68	8.24	34.49	0.00	6.64	(0.42)	0.45	$12	$15.8
Cost per day or occasion			$487	$6,818	$1,164	$1,868	$74	($1.50)	$30	—	—
Difference of seamless and traditional expected costs			$0.17	($2.31)	$13.50	($0.20)	$2.08	$0.01	$0.17	$2.58	$1.24

SOURCE: Alemi et al. (2006). Used with permission.

8.10). The expected cost of traditional probation was calculated by summing the costs associated with the pathways that followed traditional probation (rows one through four in Table 8.10). The expected cost for seamless probation was $38.84 and for traditional probation was $21.60 per follow-up day per client. The net difference was $6,293 per client per year. Seamless probation had led to reduced arrest rates ($2.31 reduction in expected cost per client per follow-up day), but this savings was not enough to compensate for the increased cost of mental hospitalization ($13.50 per client per follow-up day), increased cost for delivery of seamless probation ($2.58 per client per follow-up day), additional cost because of the use of prison/jail ($2.08 per client per follow-up day), and increased cost of providing treatment ($1.24 per client per follow-up day). Therefore, locating the clinic within probation agency had not led to savings.

Step 6: Conduct a Sensitivity Analysis

In any analysis, numerous assumptions are made. Sometimes assumptions can be wrong without changing the conclusions of the analysis. At other times, parameters need to be estimated precisely because small variations in estimates could reverse the conclusion. A sensitivity analysis can establish whether assumptions are significant enough to change the conclusions. For each parameter in the decision tree, a break-even point is found by changing the parameter until the conclusion is reversed. The percent of change to reach the break-even point is reported. In addition, where alternative estimates are available, the other estimates are used to see if conclusions change.

Decision makers are often concerned with how much confidence they should put in an analysis. Statisticians answer these concerns by measuring statistical significance of differences between the new clinic and the standard care alternative. In a decision analysis, one way to help decision makers gain confidence in the analysis is to conduct a sensitivity analysis. First, single parameters are changed. Then, two parameters are changed at the same time; finally, multiple parameters are changed. If conclusions are insensitive to reasonable changes in the parameters, then decision makers will gain confidence in the analysis.

Table 8.11 shows the sensitivity of the conclusion in the seamless probation case to changes in rates of any one of the consequences. There was no change in rates of any adverse outcome that could make seamless probation more cost-effective than traditional probation (e.g., even when the arrest rate of the seamless population was set to zero, the traditional probation was still more cost-effective). The break-even points were examined for simultaneous changes in several variables. A 54 percent reduction

TABLE 8.11 Sensitivity of Conclusion to Changes in One Estimate

	Initial Rate	*Break-even Rate*	*Percent of Initial Rate*
Changes in estimates for seamless probation			
Technical violation	0.0004	None	—
Arrest rate	0.0010	None	—
Hospitalization (mental illness)	0.0021	None	—
Hospitalization (physical illness)	0.0001	None	—
Incarceration	0.1405	None	—
Employment	0.3824	None	—
Homeless	0.0075	None	—
All adverse outcome rates	1	0.4609	46%
Arrest rates, hospitalization for mental illness, and incarceration rates	1	0.4255	43%
Arrest and mental hospitalization rates	1	None	—
Hospitalization for mental illness and incarceration rates	1	0.3130	31%
Changes in estimates for traditional probation			
Technical violation	0.0003	None	—
Arrest rate	0.0027	0.0093	339%
Hospitalization (mental illness)	0.0003	0.0193	7,042%
Hospitalization (physical illness)	0.0074	0.0925	1,245%
Incarceration	0.1075	0.3145	293%
Employment	0.3993	None	—
Homeless	0.0009	0.6597	69,877%
Cost of arrest	$6,818	$57,721	847%
Cost of seamless probation	12	None	—

in all adverse outcome rates would have made seamless probation more cost-effective than traditional probation. The analysis was most sensitive to reductions in arrest rates, hospitalization for mental illness, and incarceration rates. A 57 percent reduction in these three rates would have made seamless probation more cost-effective.

The sensitivity of conclusions to changes in any one of the estimated daily costs was examined. Note that both the traditional and seamless probation have the same daily cost for all adverse events, and therefore small changes in these estimates are unlikely to affect the difference between the two groups. For example, the daily cost of arrest is the same for both seamless and traditional probations. The cost of arrest had to increase by nearly eightfold (from $6,818 to $57,721) before the conclusion that traditional probation is more cost-effective is reversed. This analysis suggests that small variations in daily cost estimates of adverse outcomes were unlikely to affect the conclusion.

Summary

This chapter has shown how the cost-effectiveness of a clinic can be examined. A decision tree allows the calculation of cost-effectiveness to be broken down into several estimates: daily probability of enrolling in clinic services, daily probability of facing various consequences, daily cost of clinic operations, and daily cost of various consequences. The latter is available through the literature, and the former variables can be measured through tracking a large cohort of patients through subjective estimates of experts familiar with the clinic operations.

The advantage of decision analytic evaluation of a clinic is that it reduces the number of estimates needed as the daily cost of consequences can be obtained from the literature. In addition, a sensitivity analysis could be used to understand how conclusions might depend on various estimates. When conclusions are sensitive to the estimated model parameters, then additional data should be collected to improve the precision of the estimates.

These concepts were applied to the measurement of the cost-effectiveness of substance abuse clinic coordinated with traditional probation or seamless probation. The total cost of seamless probation exceeded the total cost for traditional probation by $6,293 per client per year. Sensitivity analysis suggested that the analysis was not sensitive to small changes in the estimated parameters.

Review What You Know

1. What is the meant by the terms *activity-based costing, economic cost* (distinct from accounting cost), *break-even point*, and *program census*?
2. Which of the following are used for calculating the cost of delivering a new clinic?
   a. Published changes for a day of service
   b. Accounting expenditures within the new clinic
   c. Market value of buildings and information technology used by the new clinic
3. Describe three ways of calculating a program census.
4. Describe two ways of analyzing a decision tree to obtain an expected value for each alternative in the tree.

5. What is the purpose of sensitivity analysis, and in what way is it similar to the concept of confidence intervals?
6. When comparing decision analysis and cost-benefit analysis, how does decision analysis reduce the number of estimates needed?
7. Using Excel and the data provided in Tables 8.3, 8.4 and 8.10, calculate the expected cost of consequences associated with days clients are in probation but not in treatment. This is done by first reading the data on cost and probabilities into Excel and setting the probability of null events relative to the probability of all events. Then, multiply the probability of incurring a cost by its amount and sum over all possible consequences. Make sure that all calculations are done using relative cell values and not by entering the results by hand. Check that your answers correspond roughly with the answers in Table 8.10 to make sure that formulas lead to same answers as the reading.
8. Using Excel and the data provided in Tables 8.3, 8.4, and 8.10, calculate the expected cost of seamless probation and traditional probation per client per day. These three tables show either the probability or the cost. The expected cost can be calculated as the sum of probability of incurring a cost times the dollar amount of the cost. For seamless and traditional probations, this is done by multiplying the probability of four situations—in probation and in treatment, in probation but not in treatment, not in probation but in treatment, and not in probation and not in treatment—by the cost at each of these situations. The cost at any of these situations is calculated as the cost of consequences plus the cost of the program (probation or treatment). Make sure that all calculations are done using relative cell values and not by entering the results by hand. The expected value should be calculated as the probability of the combination of probation and treatment times the cost of that combination. Check that your answers correspond roughly with the answers in the reading.
9. Conduct a sensitivity analysis on the data by making single parameter changes in the decision tree in the section on seamless probation. Before doing so, make sure that the probability of opposite events are calculated as 1 – the probability of the event. For example, make sure that the probability of not being a probation day is calculated as one minus the probability of a probation day. In this manner, if the values of a probation day change in the sensitivity analysis, all related values will change too. Report the breakeven points for the parameters in Table 8.12.
10. Draw a chart showing the sensitivity of conclusions of the analysis to changes in the probability of arrest in traditional probation. Put the

TABLE 8.12 Worksheet for Reporting Sensitivity of Conclusions

Name of Parameter Changed	*Current Value*	*Value at Break-even Point*	*Percent of Change to Reach Break-even Point*
1. Probability of a seamless probation day	______	______	______
2. Probability of treatment day given seamless probation	______	______	______
3. Probability of technical violation given seamless probation and treatment day	______	______	______
4. Probability of arrest given seamless probation and treatment day	______	______	______
5. Probability of technical violation given seamless probation day and no treatment	______	______	______
6. Probability of hospitalization (mental illness) given traditional probation and treatment days	______	______	______
7. Probability of employment given traditional probation and treatment days	______	______	______
8 Cost of treatment	______	______	______
9 Cost of seamless probation	______	______	______
10. Cost of arrest	______	______	______

probability of arrest on the x-axis. On the y-axis, put the expected cost. Draw two lines, one showing how the expected cost of seamless probation changes when the probability of arrest in the seamless probation changes from 0 to 1. Draw another line showing how the expected cost for traditional probation changes when the cost of arrest in the seamless probation changes from 0 to 1. Note the point when the two lines meet. This is the point at which the conclusion regarding which program is preferred is reversed.

11. Conduct a multi-parameter sensitivity analysis by simultaneously allowing following changes:
    a. A 30 percent increase in the cost of arrest (from $6,818 to $8,863)
    b. Any change in the probability of arrest in the seamless probation and treatment group (from 0 to 1)

c. Any change in the probability of arrest in the traditional probation and treatment group (from 0 to 1)

Report what parameters need to change to arrive at a break-even point, where current conclusions are reversed. To accomplish this assignment, instruct the Excel program to set the difference between the expected cost for traditional and seamless probations to zero subject to several constraints. Include at least the following constraints:

a. Cost of arrest < $8,863.
b. Cost of arrest > $6,818. \
c. Probability of arrest in seamless probation and treatment group > 0.
d. Probability of arrest in seamless probation and treatment group < 1.
e. Probability of arrest in traditional probation and treatment group > 0.
f. Probability of arrest in traditional probation and treatment group > 0.

Report if there is a combination of changes in these estimates that would set the difference of expected value of seamless and traditional probation equal to zero. Alternatively, you can complete this assignment by creating best- and worst-case scenarios. For each of the constraints, calculate the expected value under the worst scenario and repeat under the best scenario. If the conclusion is reversed, then the analysis is sensitive to the range of changes in the parameters.

Rapid-Analysis Exercises

1. Estimate the daily and per-visit cost of a clinic operation. The purpose of this assignment is to use the steps described here to analyze the cost of operating a clinic. To accomplish this task, use your own familiarity with the clinic operations to estimate the following:
   a. Proportion of employees working in the clinic
   b. Proportion of volunteers to employees within the clinic
   c. Proportion of patients cared for in the clinic
   d. Square footage used by the clinic based on your estimate of the square footage used by the clinic exclusively and the square footage shared among clinics
   e. Number of clients served in the organization and in the clinic in the last year or last month

f. Panel size of clinicians working in the clinic
g. Time between visits per client

2. Follow these steps to accomplish the cost analysis:
   a. Select a publicly available operating budget of a healthcare organization, preferably one in which you work or one in which you have a friend who is interested in your help in analyzing their costs.
   b. Identify the various clinics within the organization and, based on the proportion of employees who work in the clinic, allocate the operating budget to the cost of the clinic. Divide the operating budget into personnel and other operating costs. Increase the personnel expenses of the clinic proportional to the ratio of volunteers to employees within the clinic.
   c. Add the building capital costs to the clinic cost. Estimate this based on your estimated square footage used by the clinic times the market value of medical office space in the zip code of the clinic. Collect this information from real estate agents in your community or through the Internet.
   d. If the clinic relies on information systems or medical records provided by other units of the organization that are not part of the operating budget you have analyzed, add this cost into the total expense proportional to the number of clients served in the clinic.
   e. Estimate the daily clinic census from the panel size of clinicians.
   f. Estimate the number of visits of an average client (estimate this as 1 / 1 + time between visits for an average client).
   g. Estimate the total number of visits during the previous year by multiplying the number of visits of the average client by the number of clients.
   h. Report the daily cost of operating the clinic and cost per visit.
   i. Report which source of data in your analysis needs additional precision and what steps you can take to collect this information. Include estimate of how much time would be needed to collect this information.
3. Analyze the consequences of purchasing a physician primary care practice on a tertiary hospital system. Select a clinic and tertiary clinical service group, preferably settings you are familiar with or settings where you have access to someone who is familiar with the operations. Estimate the variables needed based on your knowledge of these organizations and publicly available data. Follow these steps:
   a. Create a decision model that has as its first decision node whether the to purchase or not to purchase the primary care office. The chance node should indicate the frequency of visits to the primary

care setting, the frequency of visits to specialists, and the probability of hospitalization at tertiary hospital after visit to a specialist.

b. Estimate the probabilities for the model and use publicly available estimates of the cost of clinic visits and hospital visits. Adjust the cost of hospitalization based on your estimate of differences in case mix in the tertiary hospital and the types of patients needing hospitalization in the primary care setting.
c. Report the expected increase in revenues if the office is purchased.
d. Conduct a single-variable sensitivity analysis to see which estimate is most likely to affect the expected increase in revenues. Indicate how much of the additional revenue comes from direct primary care visits and how much from subsequent referrals.
e. Report on the availability of the data needed to conduct the analysis, where you would look for each data item, and how long you think collection of the data would take.

Audio/Visual Chapter Aids

To help you understand the concepts of cost-effectiveness of clinics, visit this book's companion web site at ache.org/DecisionAnalysis, go to Chapter 8, and view the audio/visual chapter aids.

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