LEARNING OBJECTIVE 2: TO BE ABLE TO CALCULATE EXPECTED PAYOFF AND SELECTING A DECISION BASED UPON MAXIMUM PAYOFF USING SPECIFIC EXAMPLES

Health services managers make decisions under conditions of uncertainty all the time. In some instances, uncertainty may be relatively low. For example, purchasing a new imaging device to meet existing volume demands more efficiently involves a low level of uncertainty. Conversely, purchasing a new imaging device to meet an unknown demand, or to compete with another similar service provider, might represent a situation characterized by a high level of uncertainty. Consider the following examples.

Clinic Renovation

An ambulatory care clinic administrator is trying to decide whether to renovate to accommodate possible increased demand. The manager could plan a major renovation costing $700,000 that would allow 50 patients per day to be served, or a minor renovation costing $225,000 that would allow 35 patients a day to be served. The final alternative is to do nothing, thus keeping the status quo by not renovating. This continues the existing capacity of accommodating the current 20 patients per day, but no more. Presently the clinic earns $75 per patient served. Assume that the clinic is open 300 days per year and that management wants to cover the costs of the renovation from first-year earnings.

To begin quantitatively analyzing our decision options, we first go back to the three decision steps listed previously. The first step is to state the alternatives. These are to do nothing, undergo a minor renovation, or undergo a major renovation. The second step is to determine the future states of the world. These are the unknowns in our decision. Here they are the estimates of future demand. Because our decisions limit future capacity, we will use these limits as estimates of future demand. Thus, let us describe the potential for 20 patients per day, 35 patients per day, or 50 patients per day to be served, defined by current capacity, capacity given a minor renovation, and capacity given a major renovation.

There are three alternatives and three possible states of the world. This means that there are *nine* possible outcomes. These are listed in Table 10-3. The third step is to determine the payoffs for each of the potential outcomes.

Earnings are based upon patients served; therefore, part of the payoff involves earnings. For each state of the world of future demand, there are different potential maximum patients who can be seen. Each of these brings in revenue of $75. This amount is then multiplied by the 300 days the clinic is open yearly to calculate the total revenue per year. The maximum revenue generated in each state of the world can be seen in Table 10-4.

Table 10-3 Expected Outcomes for Clinic Renovation

Alternative	*State of the world (future demand forecasts)*	*Outcome*
No renovation/do nothing	Demand remains at 20 patients per day	Demand is met
No renovation/do nothing	Demand increases to 35 patients per day	Demand is not met
No renovation/do nothing	Demand increases to 50 patients per day	Demand is not met
Minor renovation	Demand remains at 20 patients per day	Demand is met
Minor renovation	Demand increases to 35 patients per day	Demand is met
Minor renovation	Demand increases to 50 patients per day	Demand is not met
Major renovation	Demand remains at 20 patients per day	Demand is met
Major renovation	Demand increases to 35 patients per day	Demand is met
Major renovation	Demand increases to 50 patients per day	Demand is met

Table 10-4 Potential Monetary Payoffs by States of the World

Future demand forecasts (patients per day)	*Payment per patient*	*Days open*	*Total yearly payment*
20	$75.00	300	$450,000.00
35	$75.00	300	$787,500.00
50	$75.00	300	$1,125,000.00

In addition to revenue, however, clinic renovations cost money that must be charged against these earnings. Remember that doing nothing carries no renovation expense, whereas minor and major renovations cost $225,000 and $700,000 respectively. Table 10-5 lists the revenue, cost, and payoff for each decision alternative.

It is important to remember that the potential demand is uncertain. The clinic does not know for certain whether the demand will continue to be 20, 35, or 50 patients per day. It is quite possible that if a major renovation is undertaken, only 35 patients per day show up or are booked. At this point in this example, one management approach would be to use expert opinion or mathematical forecasting to predict the future demand and base the subsequent analysis upon the "certainty" associated with the forecast. Such insight may help determine how probable future demand might be and could assist in choosing an alternative.

Another approach is to assume that all states of the world are equally likely to occur. In this example doing so would mean that the probability of current demand (20 patients per day) would be 0.3333, moderate demand (35 patients per day) would be 0.3333, and high demand (50 patients per day) would be 0.3333, thus setting them equal.

Remember that states of the world are future unknown events. They are beyond the power of the decision maker to know. However, there may be data or other information that can assist in altering our probabilities of a future event, such as the case with the decision to carry an umbrella earlier in the chapter. In that instance, a weather forecast could have provided valuable information about setting the probabilities of rain. When the future is truly unknown, setting probabilities equal is a good starting rationale. Once probabilities for each state of the world have been determined, the expected total payoff for each can be determined. Remember again that each state of the world in this example has three potential outcomes (see Tables 10-3 and 10-5). Only one of these *will* occur. Thus for each state of the world all probabilities must add up to 1 (or 100%). To calculate the expected total payoff for each state of the world, we simply multiply each outcome's payoff by its probability of occurrence, and sum them.

Table 10-5 Revenues, Expenses, and Expected Payoffs for Clinic Renovation

Alternative	*State of the world (future demand forecasts)*	*Earnings*	*Renovation expense*	*Payoff*
No Renovation/Do Nothing	20	$450,000	0	$450,000
No Renovation/Do Nothing	20	$450,000	0	$450,000
No Renovation/Do Nothing	20	$450,000	0	$450,000
Minor Renovation	20	$450,000	$225,000	$225,000
Minor Renovation	35	$787,500	$225,000	$562,500
Minor Renovation	35	$787,500	$225,000	$562,500
Major Renovation	20	$450,000	$700,000	($250,000)
Major Renovation	35	$787,500	$700,000	$87,500
Major Renovation	50	$1,125,000	$700,000	$425,000

Using equal probabilities our expected total payoff (ETP) for each decision payoff in Table 10-5 we find:

1. Expected Payoff [no renovation] = (0.33) × $450,000 + (0.33) × $450,000 + (0.33) × $450,000 = $450,000
2. Expected Payoff [minor renovation] = (0.33) × 225,000 + (0.33) × $562,500 + (0.33) × $562,500 = $445,500
3. Expected Payoff [minor renovation] = (0.33) × $250,000 + (0.33) × $87,500 + (0.33) × $425,000 = $86,625

In this case, the clinic management would choose the higher of the expected total payoffs, or the decision associated with $450,000—to do nothing and continue at present capacity. What is important to note, however, is how close the ETP values are for decision alternatives one and two. One might wonder, as we did in the umbrella example, what probability would cause us to make a different decision. Because we are dealing with three and not two decisions, we cannot calculate a break even set of probabilities per se. What we can do is alter our probabilities slightly to assess the changes in our ETP and thus our choice.

Perhaps the clinic management anticipates they would conduct marketing in the community concurrent with construction to increase demand. Let us say that they think there is a 10% chance that demand will remain at 20 per day and there is a 50% chance that demand will increase to 35 per day. This means they are implicitly assigning the probabilities of 0.1 to low future demand, and 0.5 to moderate future demand, leaving 0.4 left over for high future demand, or a 40% chance.

Expected Payoff [no renovation] = (0.1) × $450,000 + (0.5) × $450,000 + (0.4) × $450,000 = $450,000

Expected Payoff [minor renovation] = (0.1) × 225,000 + (0.5) × $562,500 + (0.4) × $562,500 = $528,750

Expected Payoff [major renovation] = (0.1) × −$250,000 + (0.5) × $87,500 + (0.4) × $425,000 = $238,750

In this case, the clinic management would change their decision to choose a minor renovation strategy because the expected payoff is the greatest. Notice that this is true *even though* the probability of high demand is less than that of moderate demand. Thus, all conditions before the decision being equal, decision analysis tells the manager to choose a minor renovation.

Example 2: Bid for Services

You are part of a consulting firm that is considering bidding on a project to set up a pricing plan for cardiovascular treatment procedures. You will determine the