6.12: Probability Rules (1 of 3)

Learning Objectives

- Reason from probability distributions, using probability rules, to answer probability questions.

In our previous discussions of probability, we focused on determining the probability of one event at a time. For example, we used two-way tables in *Relationships in Categorical Data with Intro to Probability* to find the probability that a randomly selected female student from a community college is a Health Science major.

Now we shift our focus to describing the probabilities of all possible outcomes instead of the probability of just one outcome.

We think of all possible outcomes as variable values. Each variable value has a probability. The variable values together with their probabilities are a **probability distribution**.

Example

Probability Distribution for Blood Type

Consider the variable *blood type*. This is a categorical variable with variable values A, B, AB, or O. Using relative frequencies from large samples of randomly chosen individuals, we can estimate the probability of choosing a person with a given blood type. Using relative frequencies, the Stanford University's Blood Center (bloodcenter.stanford.edu) gives the probabilities of human blood types in the United States as follows:

Blood Type	O	A	B	AB
Probability	0.45	0.41	0.10	0.04

This table is an example of a probability distribution. Each variable value is assigned a probability.

Notice the following important fact about this probability distribution:

The sum of all of the probabilities is 1. This makes sense because we have listed all the outcomes. Since each probability is a relative frequency, these outcomes make up 100% of the observations.

We can use the probability distribution to answer probability questions:

> **Question:** People with blood type O can donate blood to people with any other blood type. For this reason, people with blood type O are called universal donors. *What is the probability that a randomly selected person from the United States is a universal donor?*
> **Answer***P*(universal donor) = *P*(blood type O) = 0.45. There is a 45% chance that a randomly selected person in the United States is a universal donor.

Example

Probability Distribution for Boreal Owl Eggs

Boreal owls are common in Canada and Alaska. They are fairly small, averaging 10 inches in length and weighing from 4 to 6 oz. They often make their nests in woodpecker holes. The number of eggs in a boreal owl nest generally ranges from 4 to 6 eggs. Using relative frequencies from large field observations, we can estimate the probability of a nest containing a certain number of eggs.

The variable is *Boreal owl eggs in a nest*. This is a quantitative variable with values 0, 1, 2, 3, 4, 5, or 6 eggs. The probability distribution gives the probability that a nest will have from 0 to 6 eggs.

Number of Eggs	0	1	2	3	4	5	6
Probability	0.2	0.1	0.1	0.25	0.25	0.05	0.05

This table is also an example of a probability distribution. Each variable value is assigned a probability.

Note: *The sum of all of the probabilities is 1*. This is always true for a probability distribution.

We can use the probability distribution to answer probability questions:

> **Question:** *Which is more likely: (1) To find a boreal owl nest with 3 eggs, or (2) To find a boreal owl nest with 4 eggs.*
> **Answer** Both of these events are equally likely. $P(3 \text{ eggs}) = P(4 \text{ eggs}) = 0.25$. There is a 25% chance that if you find a boreal owl nest, it will have 3 eggs. You are equally likely to find a boreal owl nest with 4 eggs.

Notice the following important facts about probability distributions:

- *The outcomes are random events.* When we randomly choose a person, we do not know their blood type. But there is a predictable pattern in the outcomes that is described by the relative frequencies. When we randomly select a boreal owl nest, we do not know how many eggs it will contain, but there is a predictable pattern in the outcomes that is described by the relative frequencies.
- *All outcomes are assigned a probability.*
- *The probabilities are numbers between 0 and 1.* This makes sense because each probability is a relative frequency.
- *The sum of all of the probabilities is 1.* This makes sense because we have listed all the outcomes. Since each probability is a relative frequency, these outcomes make up 100% of the observations.

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