What are the chances?

INTRODUCTION TO STATISTICS IN R

Maggie Matsui
Content Developer, DataCamp

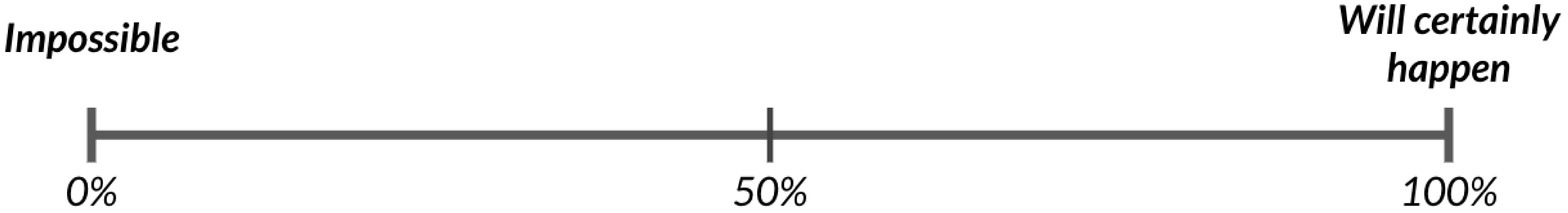
Measuring chance

What's the probability of an event?

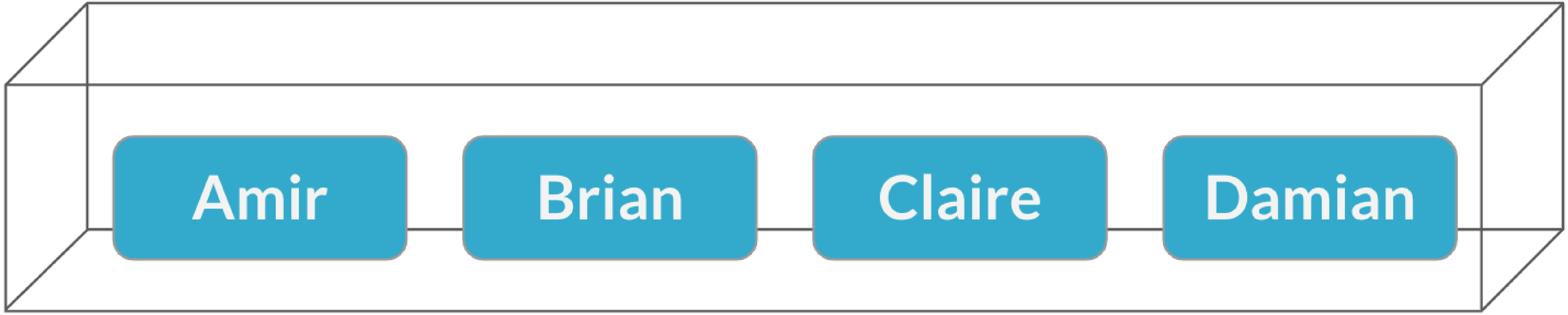
$$P(\text{event}) = \frac{\#\text{ ways event can happen}}{\text{total }\#\text{ of possible outcomes}}$$

Example: a coin flip

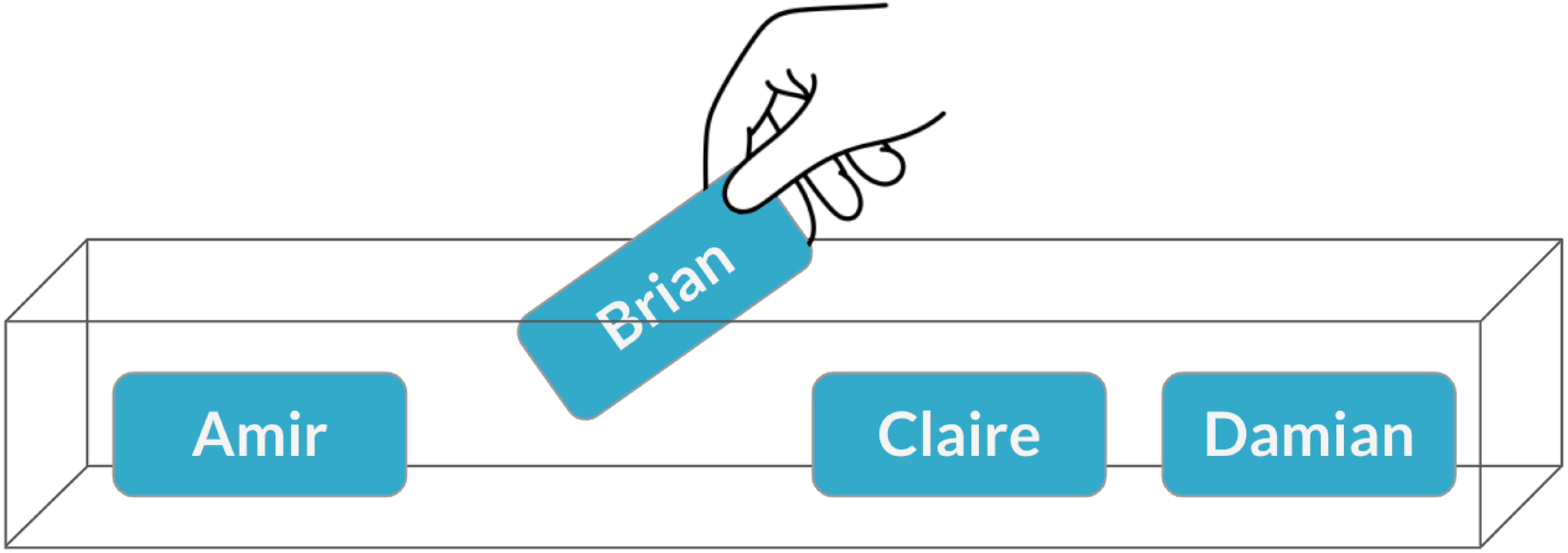
$$P(\text{heads}) = \frac{1\text{ way to get heads}}{2\text{ possible outcomes}} = \frac{1}{2} = 50\%$$



Assigning salespeople



Assigning salespeople



$$P(\text{Brian}) = \frac{1}{4} = 25\%$$

Sampling from a data frame

```
sales_counts
```

```
    name   n_sales
1 Amir        178
2 Brian       126
3 Claire       75
4 Damian       69
```

```
sales_counts %>%
  sample_n(1)
```

```
    name   n_sales
1 Brian       126
```

```
sales_counts %>%
  sample_n(1)
```

```
    name   n_sales
1 Claire       75
```

Setting a random seed

```r
set.seed(5)
sales_counts %>%
  sample_n(1)
```

```
   name  n_sales
1 Brian      126
```

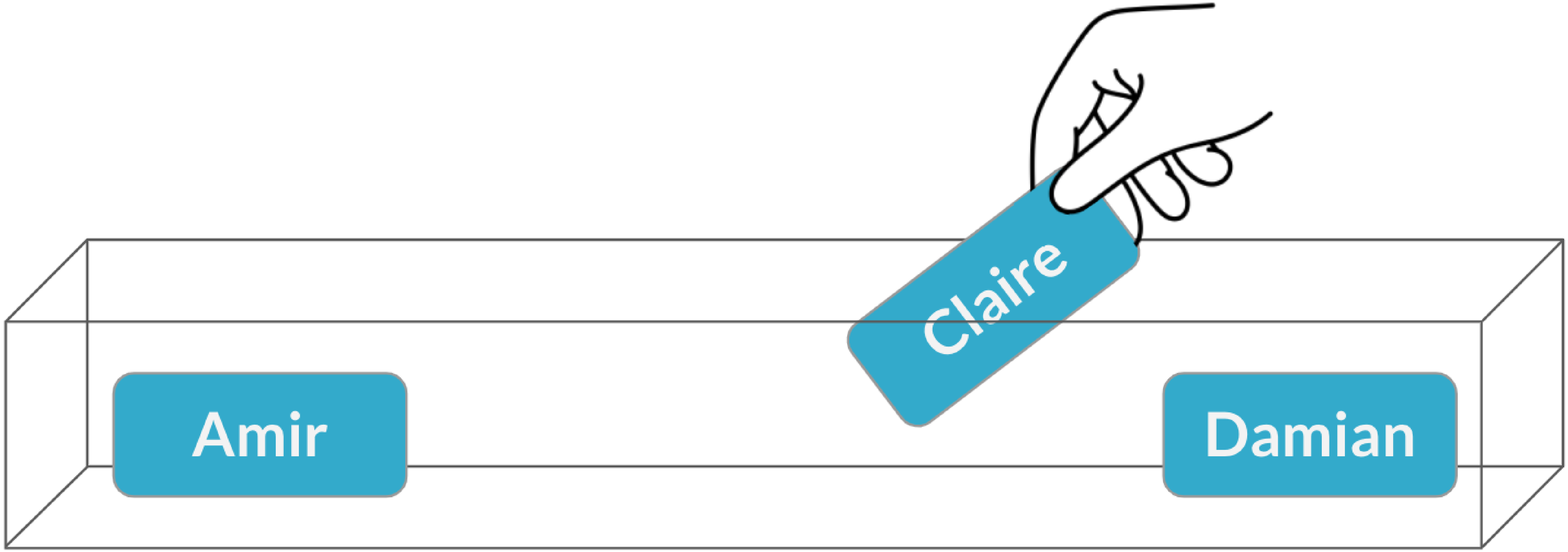
```r
set.seed(5)
sales_counts %>%
  sample_n(1)
```

```
   name  n_sales
1 Brian      126
```

A second meeting

Sampling without replacement

A second meeting



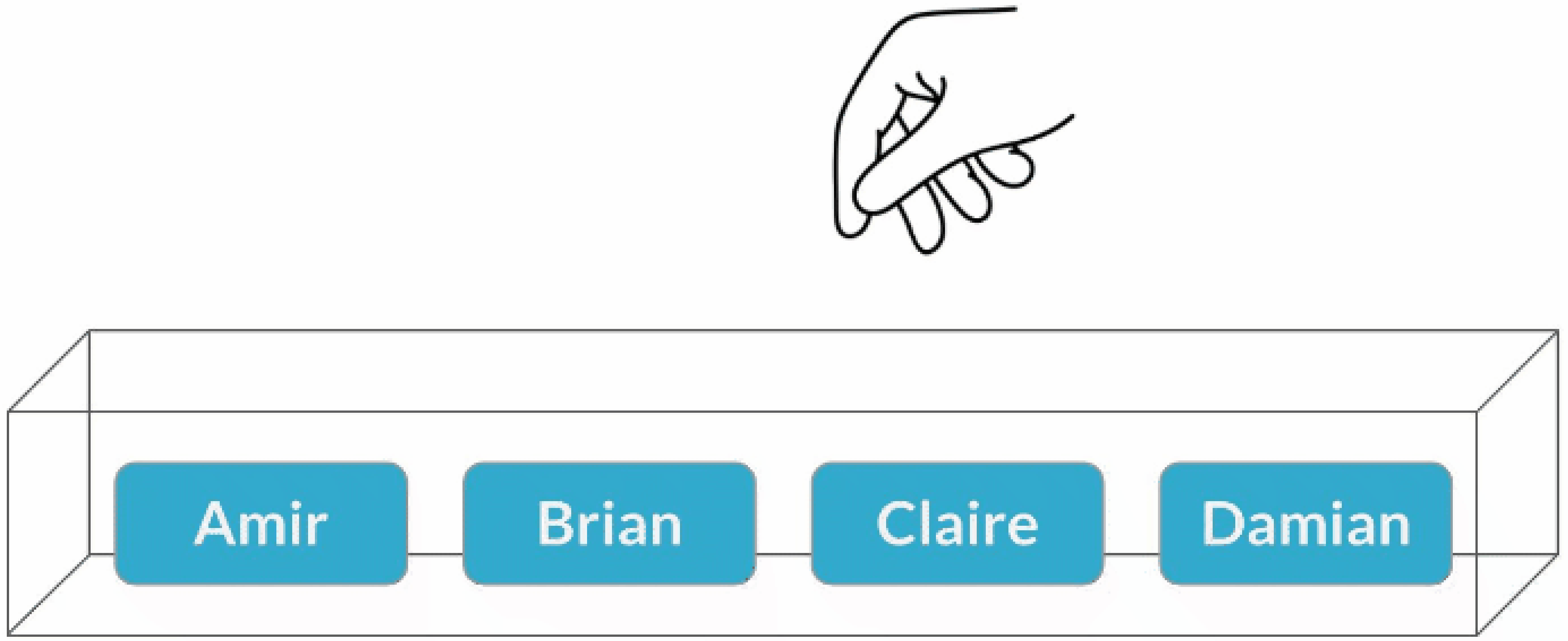
$$P(\text{Claire}) = \frac{1}{3} = 33\%$$

Sampling twice in R

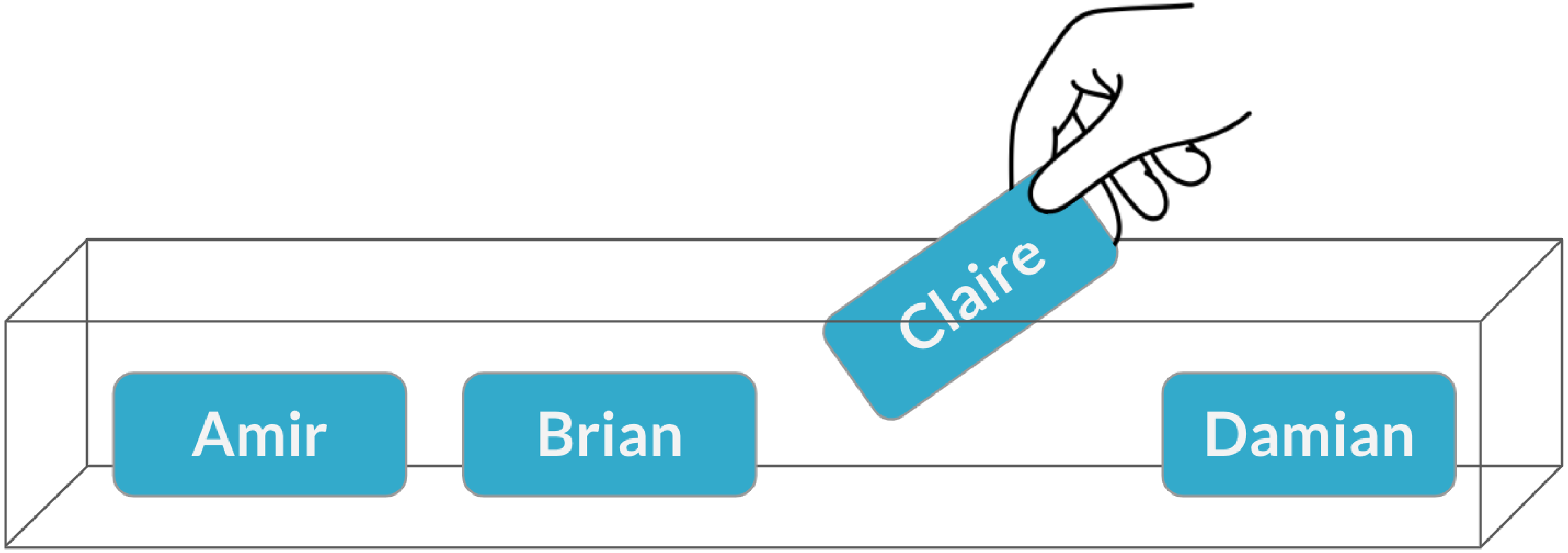
```
sales_counts %>%
  sample_n(2)
```

```
    name   n_sales
1  Brian       126
2  Claire       75
```

Sampling with replacement



Sampling with replacement



$$P(\text{Claire}) = \frac{1}{4} = 25\%$$

Sampling with replacement in R

```
sales_counts %>%
  sample_n(2, replace = TRUE)
```

```
   name   n_sales
1  Brian      126
2  Claire      75
```

5 meetings:

```
sample(sales_team, 5, replace = TRUE)
```

```
   name   n_sales
1  Brian      126
2  Claire      75
3  Brian      126
4  Brian      126
5  Amir       178
```

Independent events

*Two events are **independent** if the probability of the second event **isn't** affected by the outcome of the first event.*

Sampling with Replacement

First pick | *Second pick*

Amir

Brian

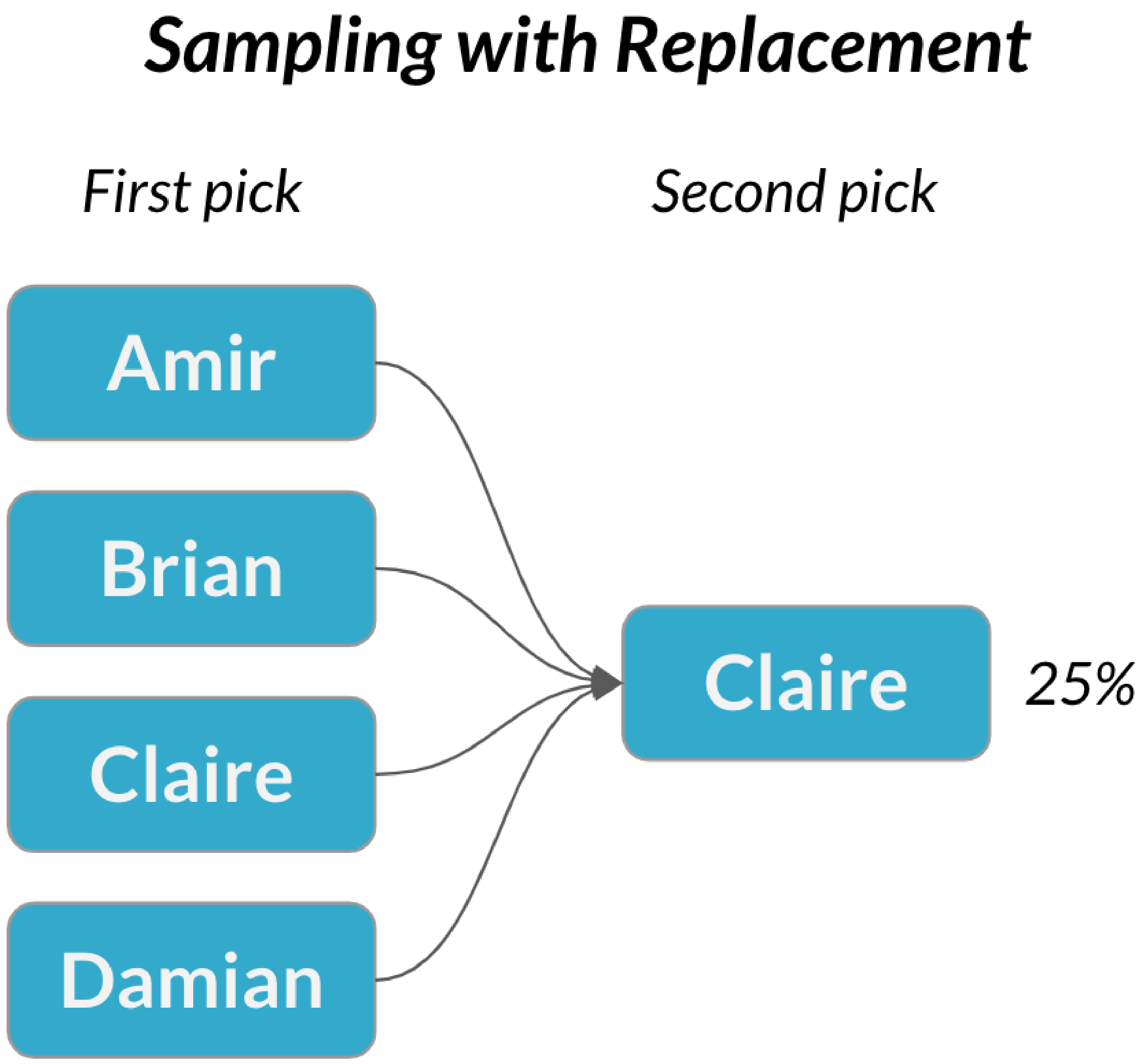
Claire

Damian

Independent events

*Two events are **independent** if the probability of the second event **isn't** affected by the outcome of the first event.*

Sampling with replacement = each pick is independent



Dependent events

*Two events are **dependent** if the probability of the second event **is** affected by the outcome of the first event.*

Sampling without Replacement

First pick | *Second pick*

Amir

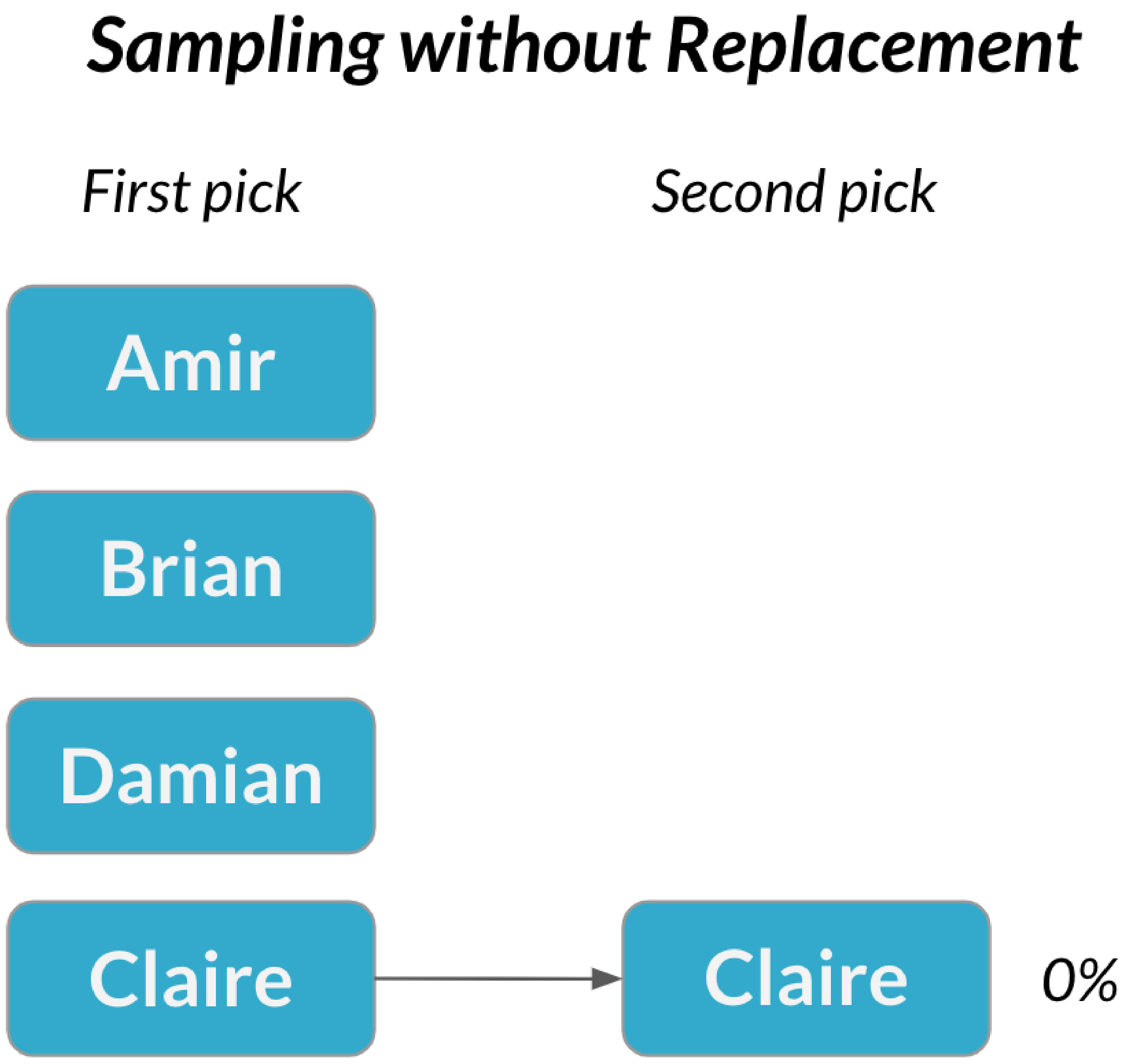
Brian

Damian

Claire

Dependent events

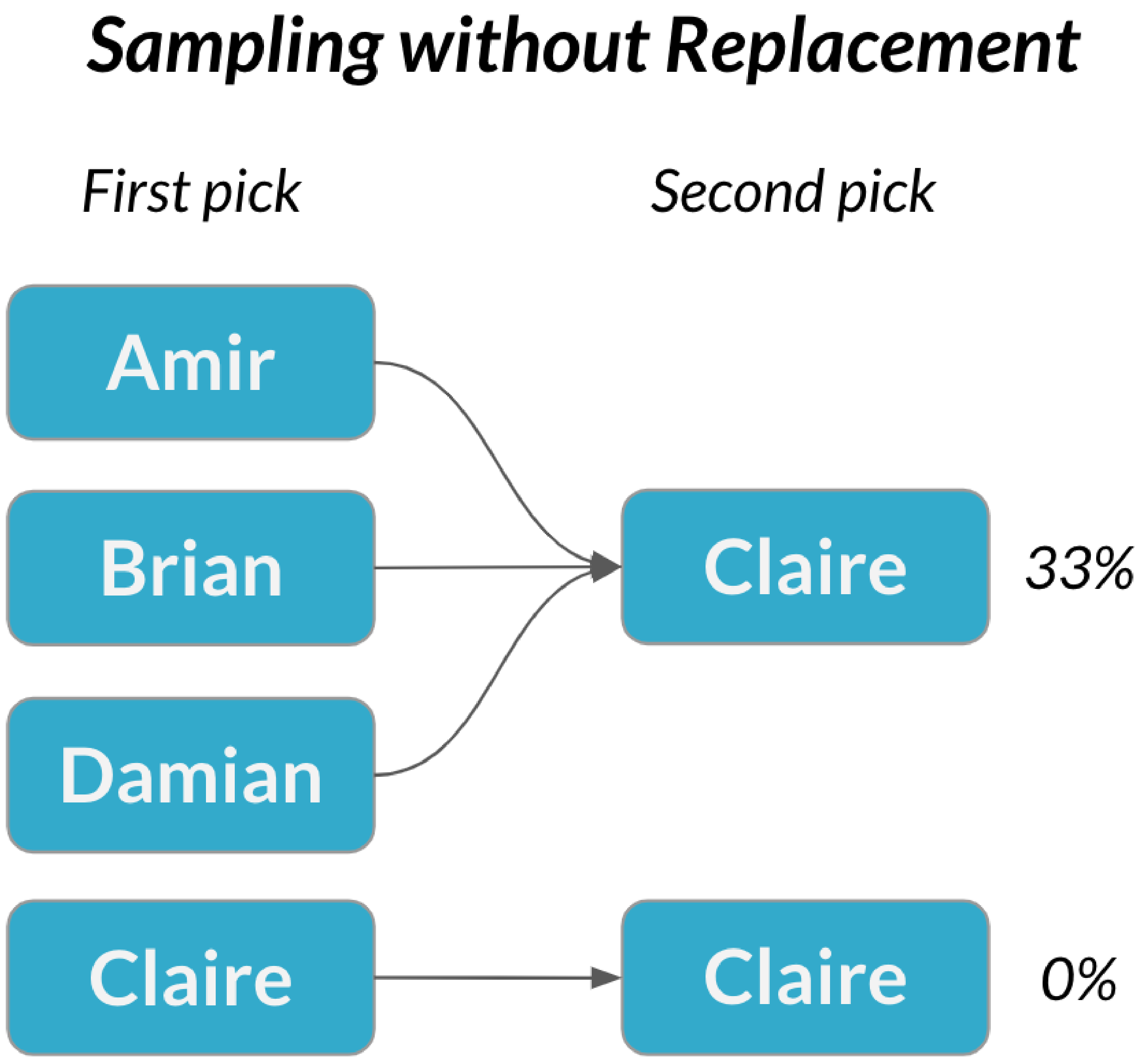
*Two events are **dependent** if the probability of the second event **is** affected by the outcome of the first event.*



Dependent events

*Two events are **dependent** if the probability of the second event **is** affected by the outcome of the first event.*

Sampling without replacement = each pick is dependent



Let's practice!

INTRODUCTION TO STATISTICS IN R

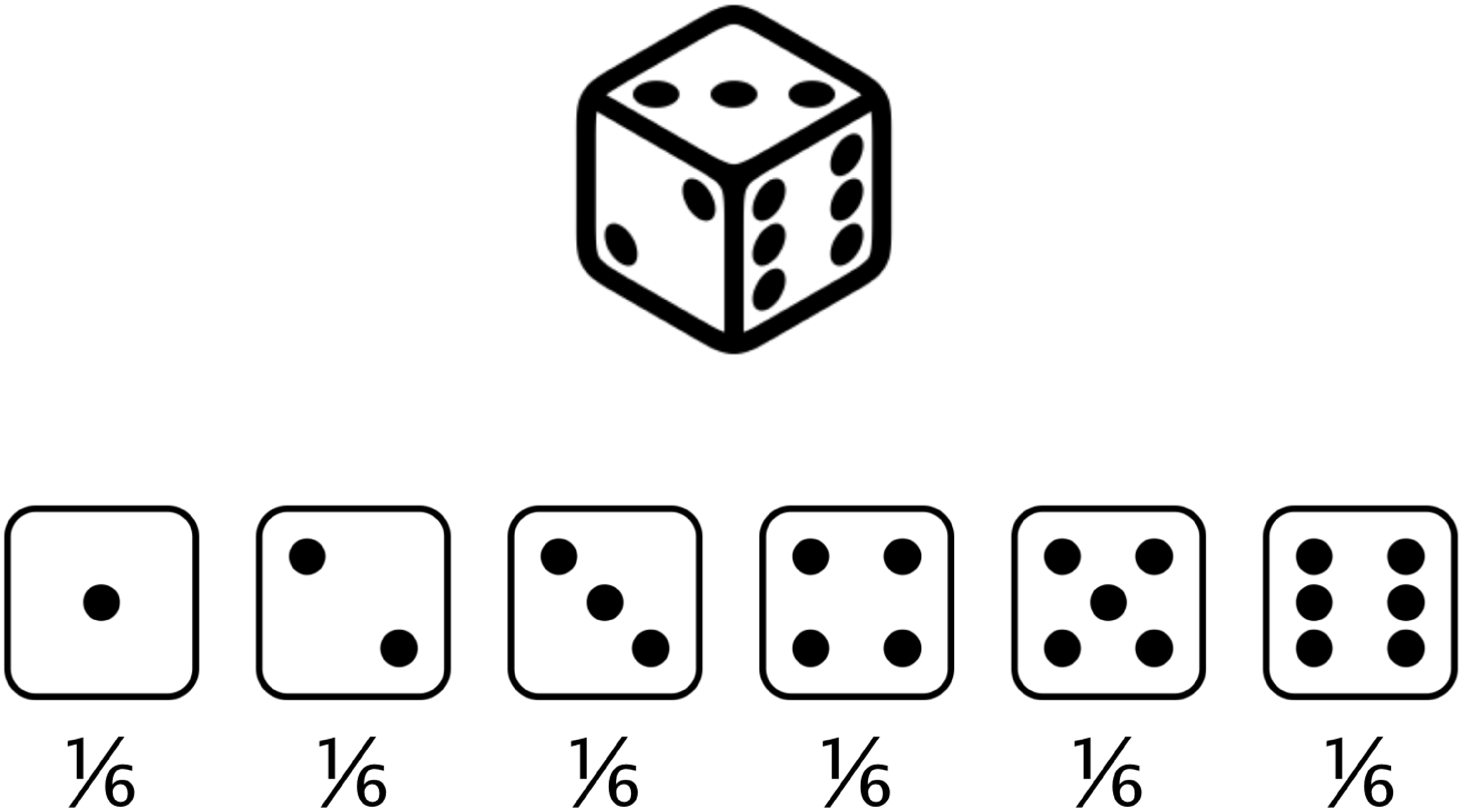
Discrete distributions

INTRODUCTION TO STATISTICS IN R

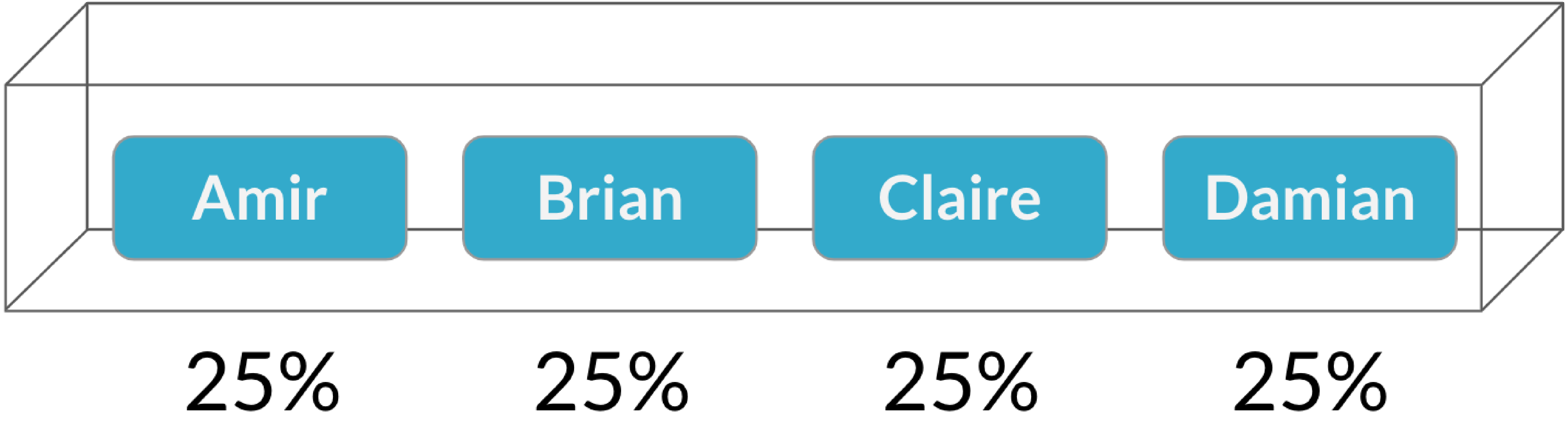
Maggie Matsui
Content Developer, DataCamp

Rolling the dice

Rolling the dice

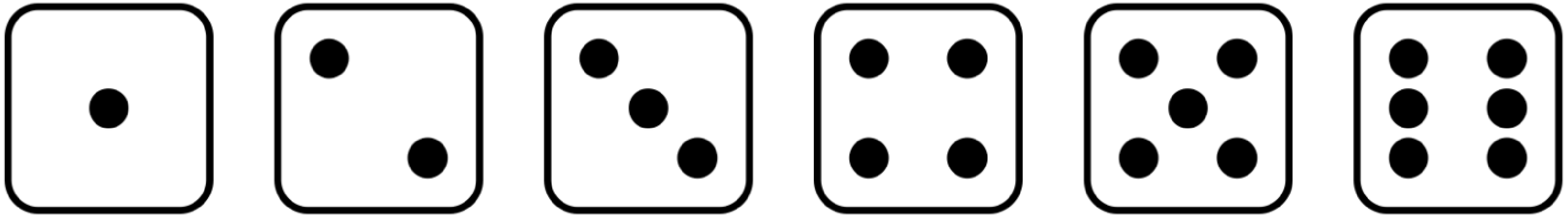


Choosing salespeople



Probability distribution

Describes the probability of each possible outcome in a scenario



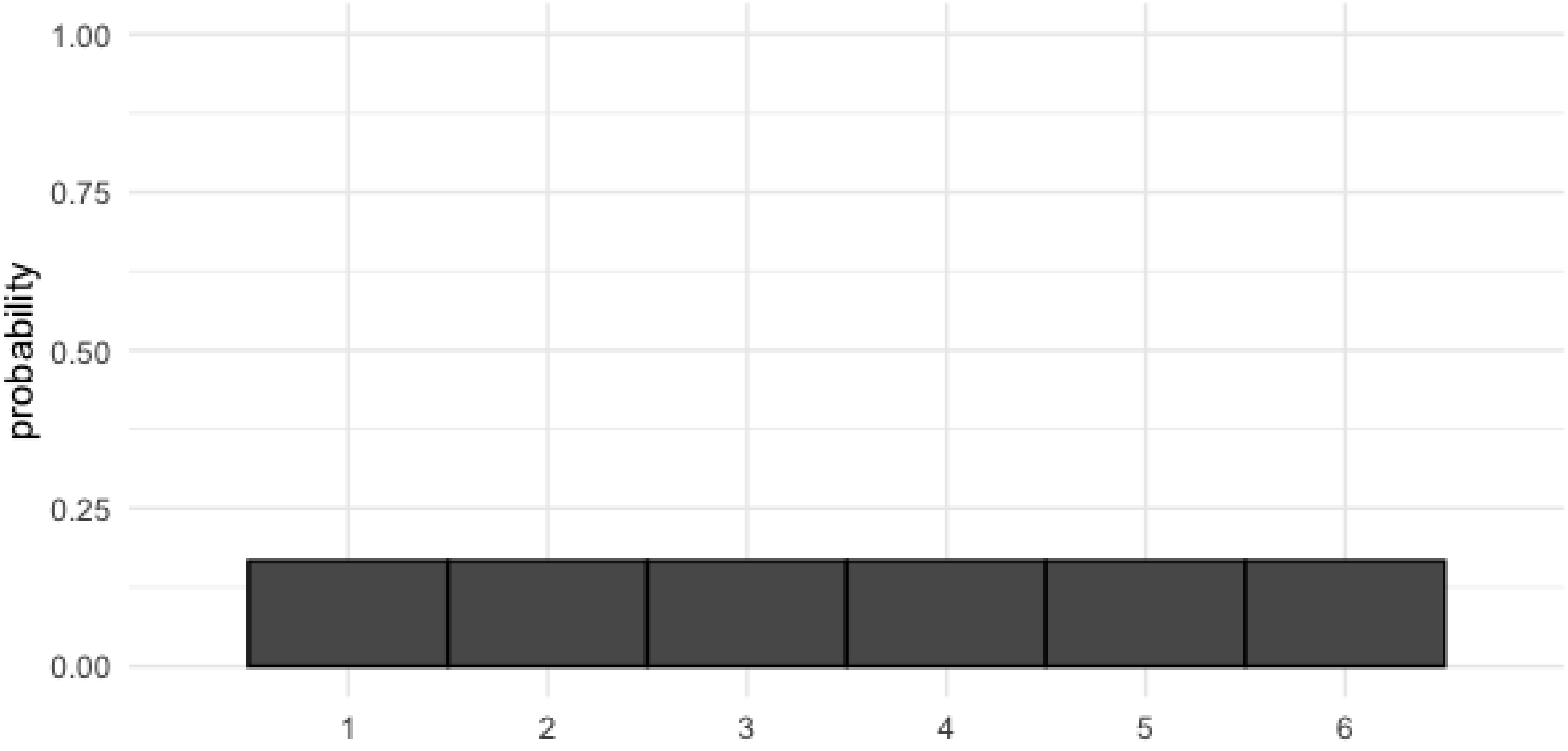
⅙ ⅙ ⅙ ⅙ ⅙ ⅙

Expected value: mean of a probability distribution

Expected value of a fair die roll =

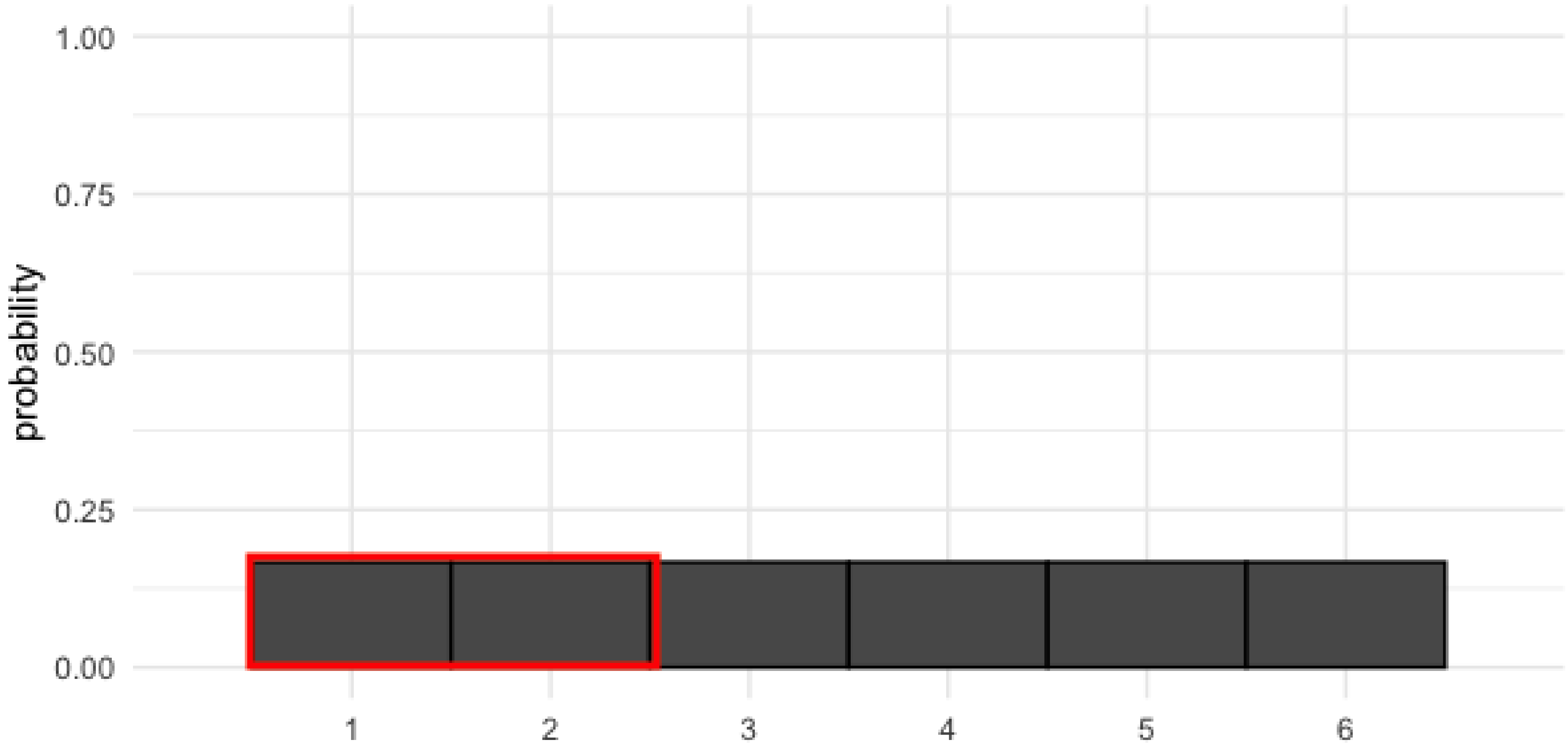
$$(1 \times \frac{1}{6}) + (2 \times \frac{1}{6}) + (3 \times \frac{1}{6}) + (4 \times \frac{1}{6}) + (5 \times \frac{1}{6}) + (6 \times \frac{1}{6}) = 3.5$$

Visualizing a probability distribution



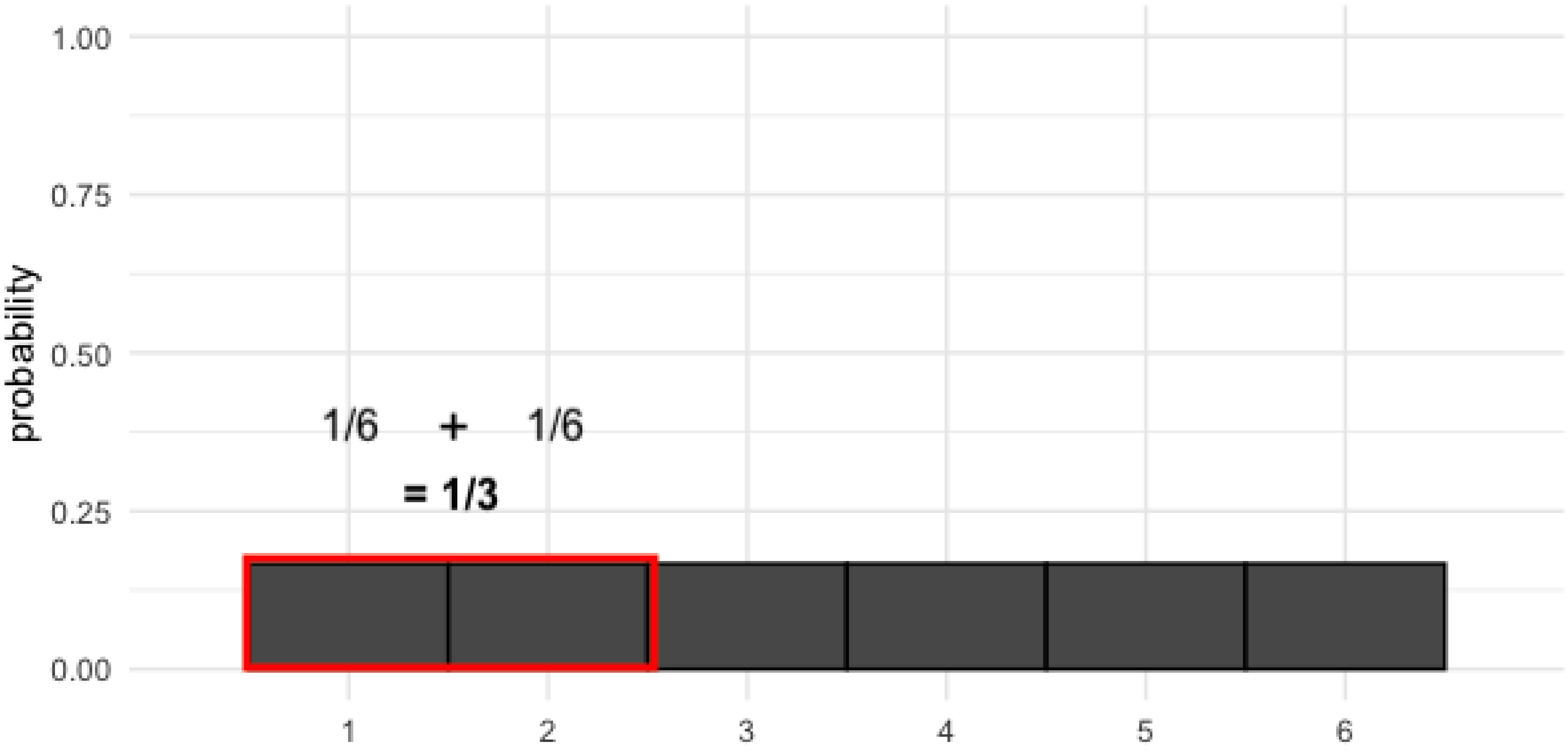
Probability = area

$$P(\text{die roll}) \leq 2 = ?$$

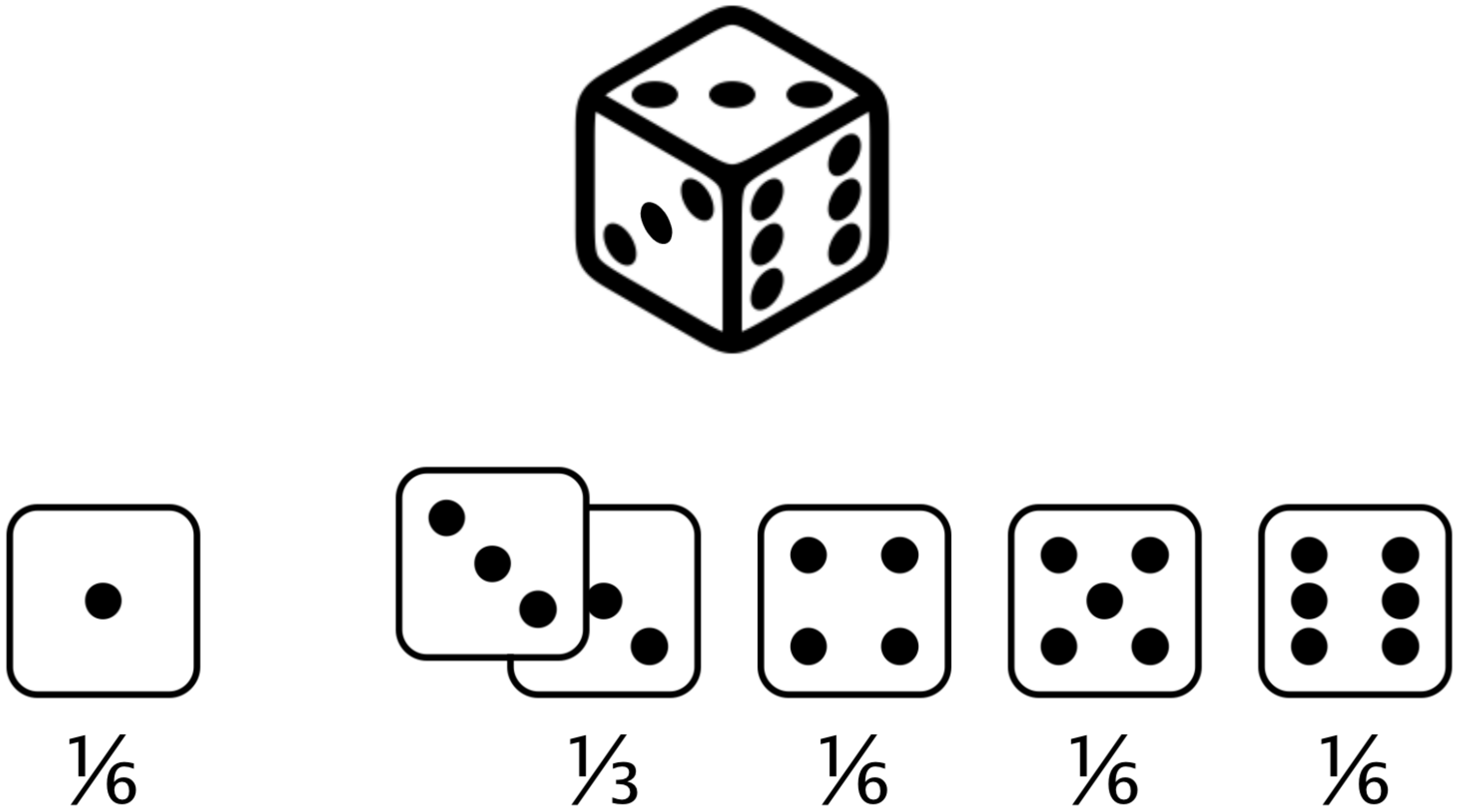


Probability = area

$$P(\text{die roll}) \leq 2 = 1/3$$



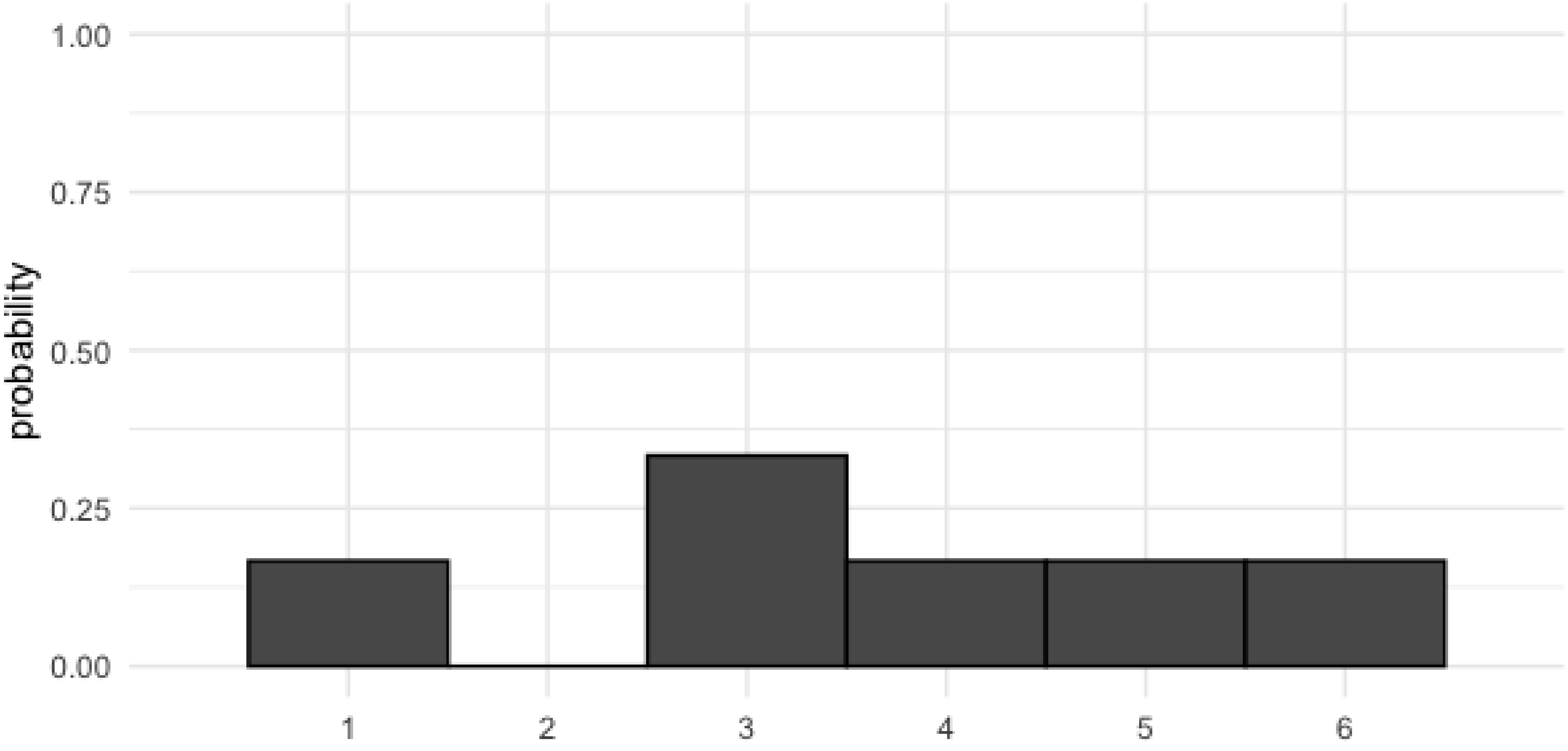
Uneven die



Expected value of uneven die roll =

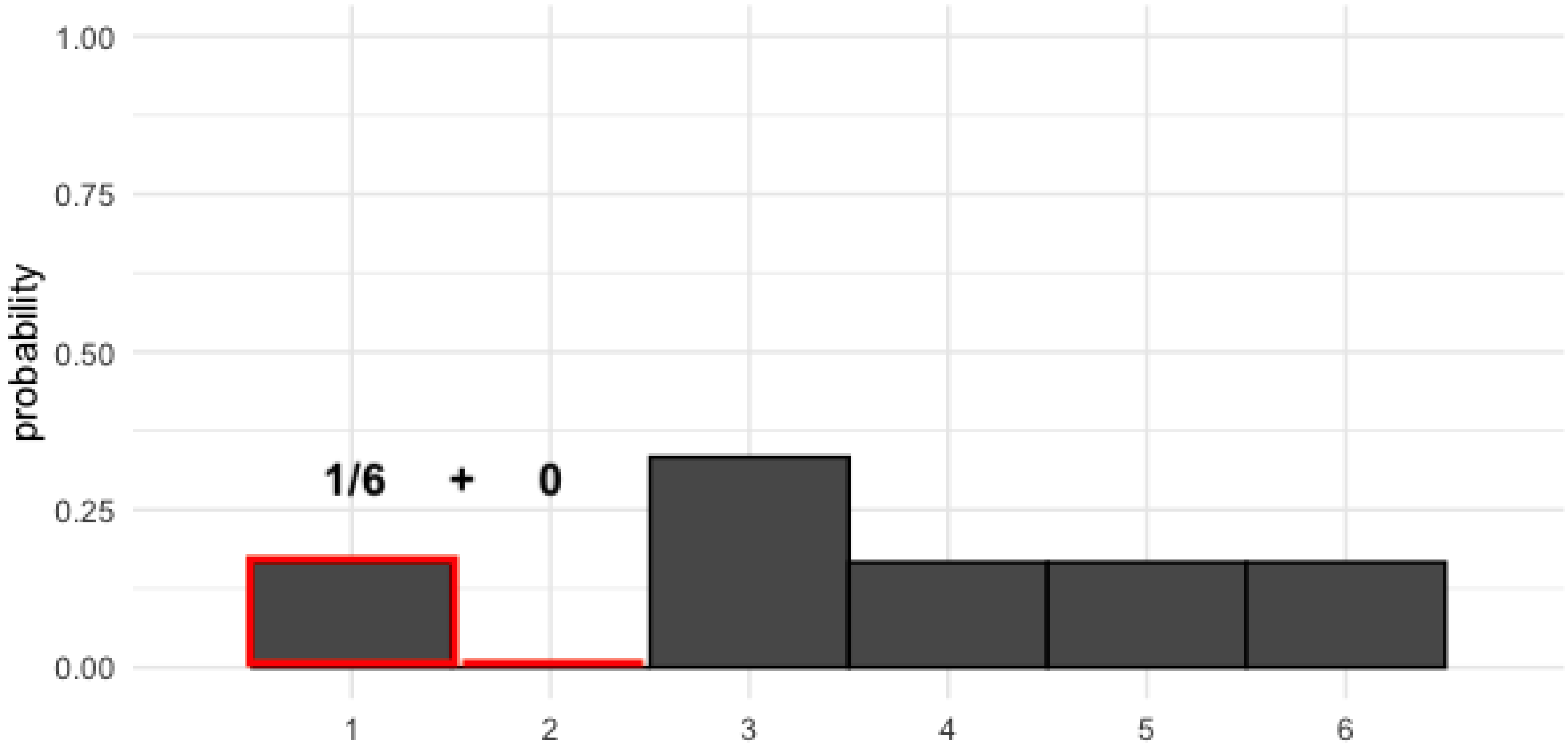
$$(1 \times \frac{1}{6}) + (2 \times 0) + (3 \times \frac{1}{3}) + (4 \times \frac{1}{6}) + (5 \times \frac{1}{6}) + (6 \times \frac{1}{6}) = 3.67$$

Visualizing uneven probabilities



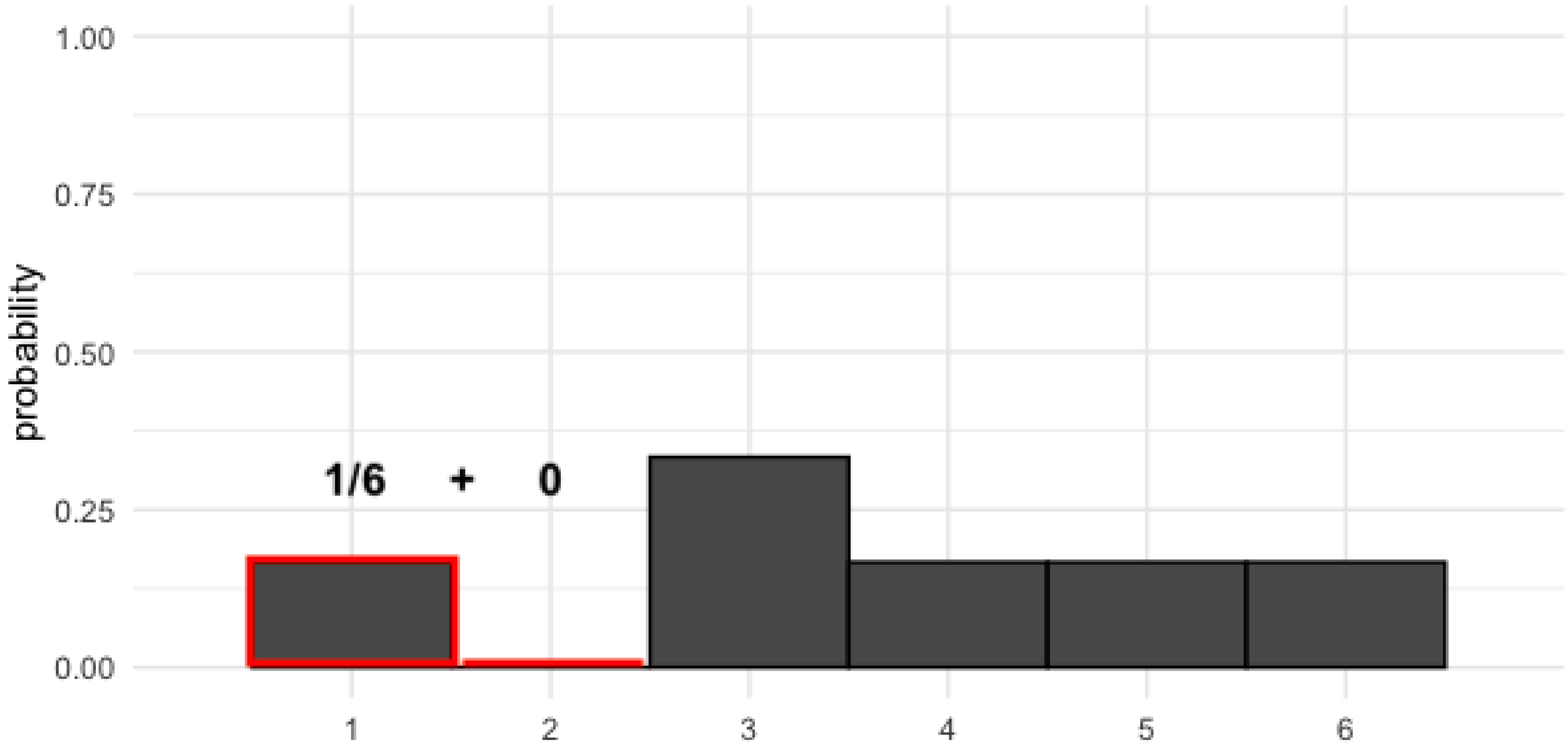
Adding areas

$$P(\text{uneven die roll}) \leq 2 = ?$$



Adding areas

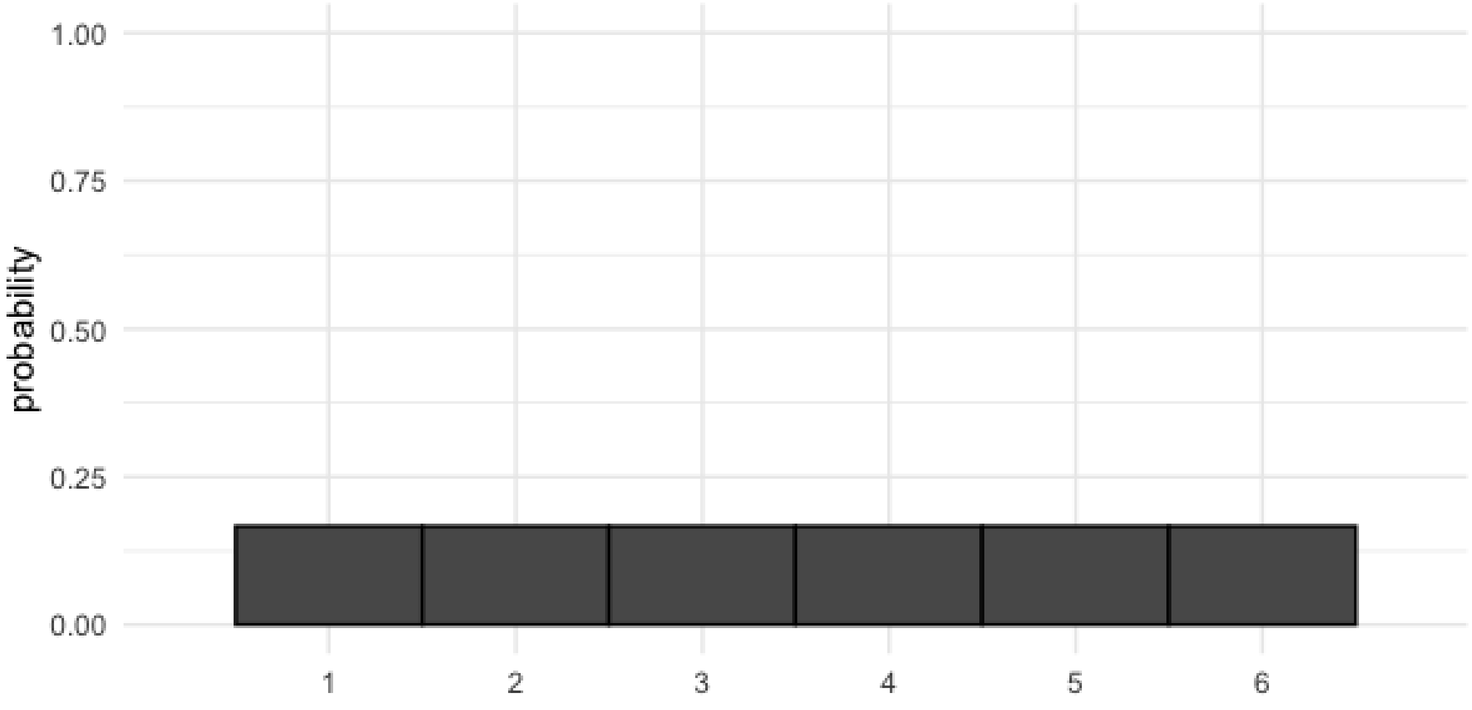
$$P(\text{uneven die roll}) \leq 2 = 1/6$$



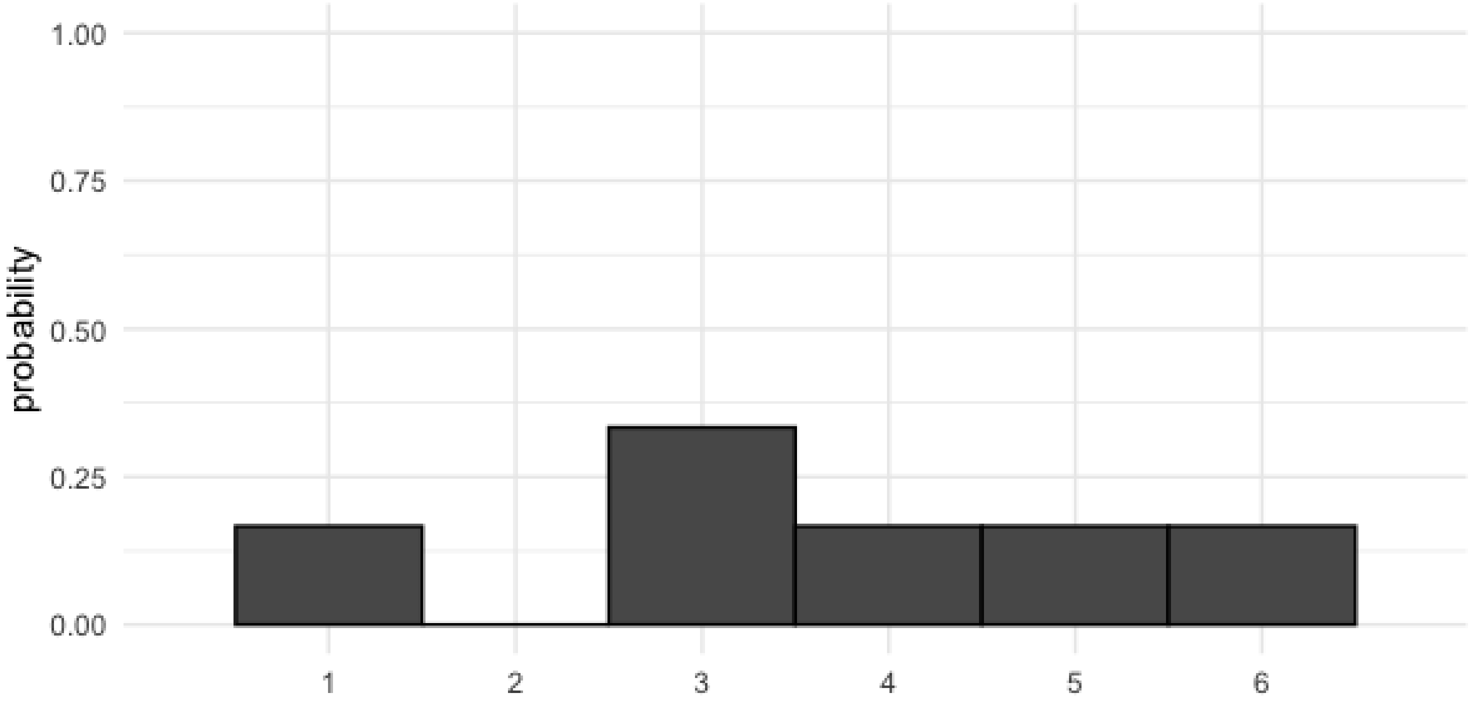
Discrete probability distributions

Describe probabilities for discrete outcomes

Fair die



Uneven die



Discrete uniform distribution

Sampling from discrete distributions

```
die
```

```
  n
1 1
2 2
3 3
4 4
5 5
6 6
```

```
mean(die$n)
```

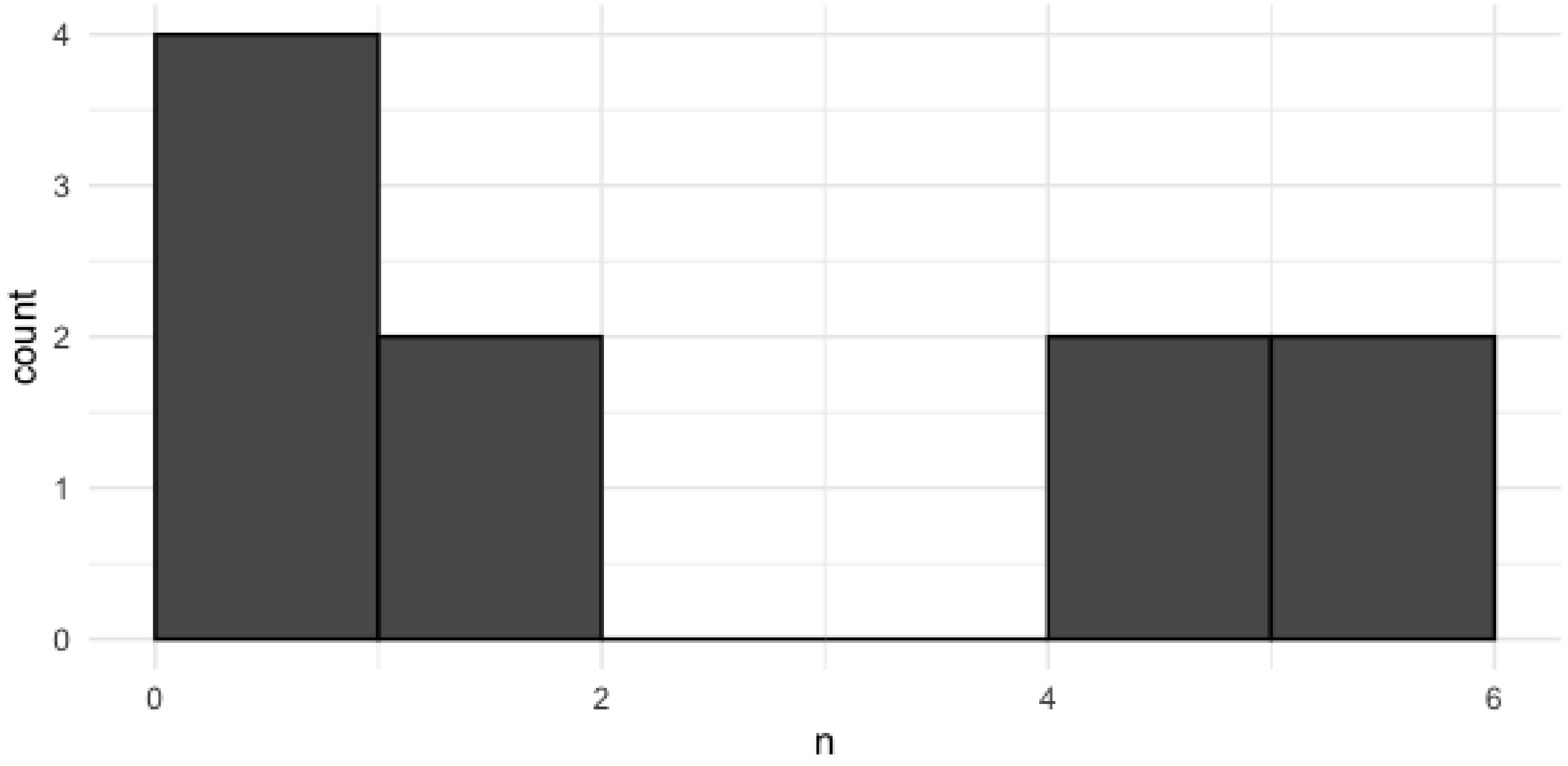
```
3.5
```

```
rolls_10 <- die %>%
  sample_n(10, replace = TRUE)
rolls_10
```

```
  n
1 1
2 1
3 5
4 2
5 1
6 1
7 6
8 6
...
```

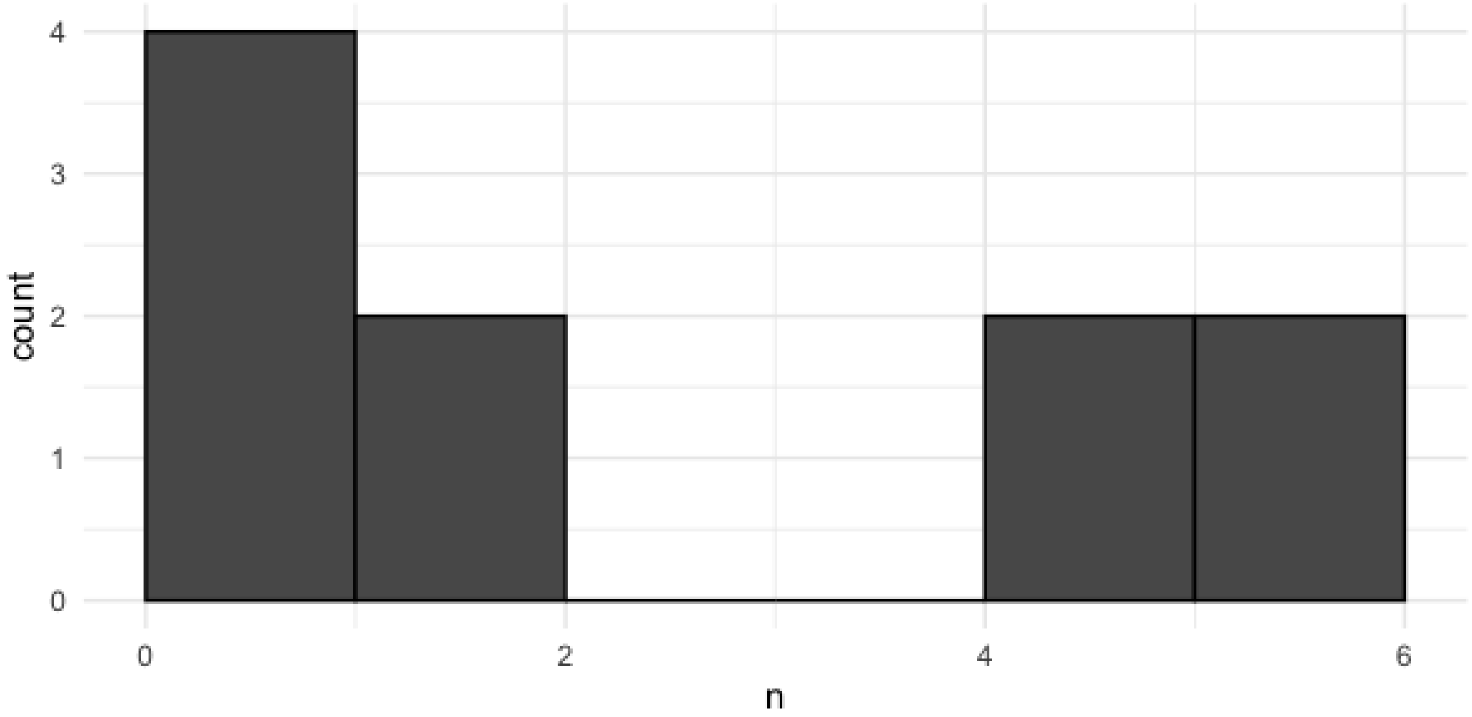
Visualizing a sample

```
ggplot(rolls_10, aes(n)) +
  geom_histogram(bins = 6)
```



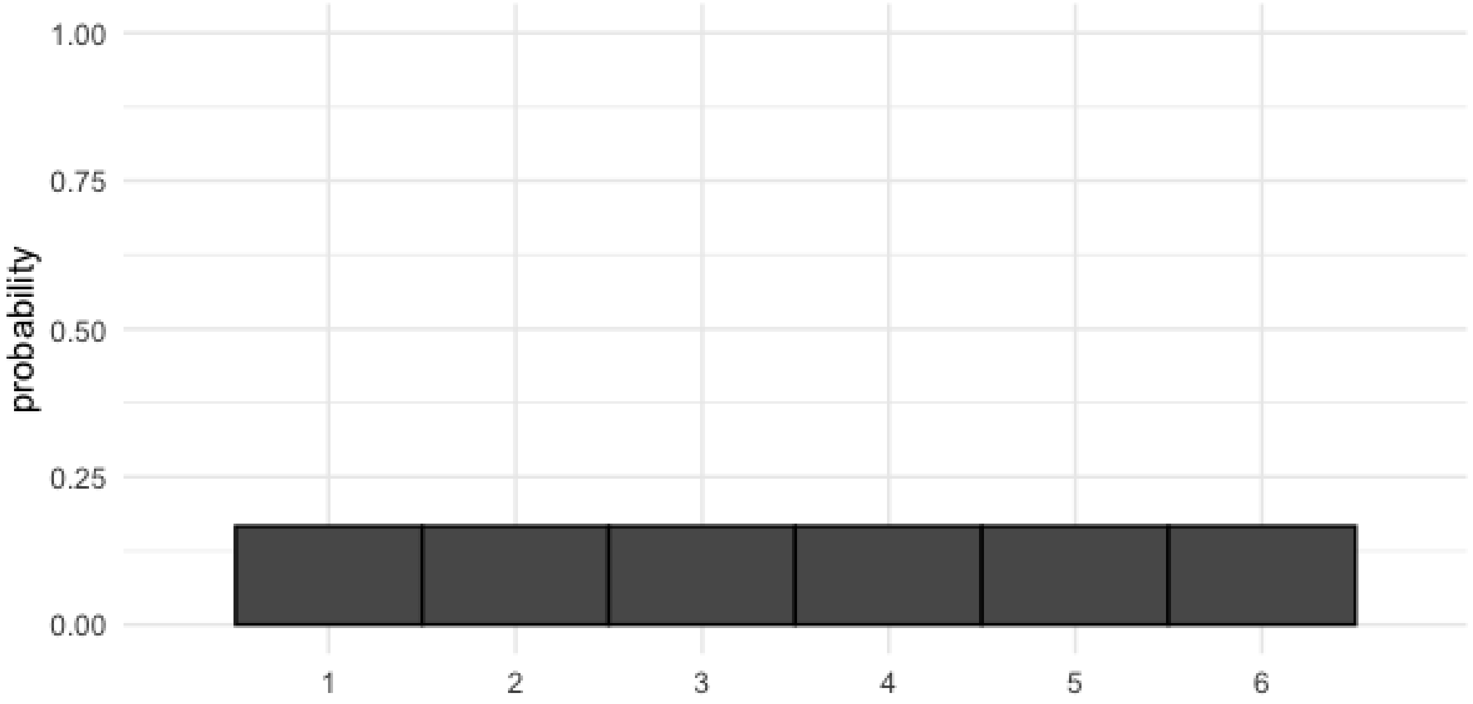
Sample distribution vs. theoretical distribution

Sample of 10 rolls



`mean(rolls_10$n)` = `3.0`

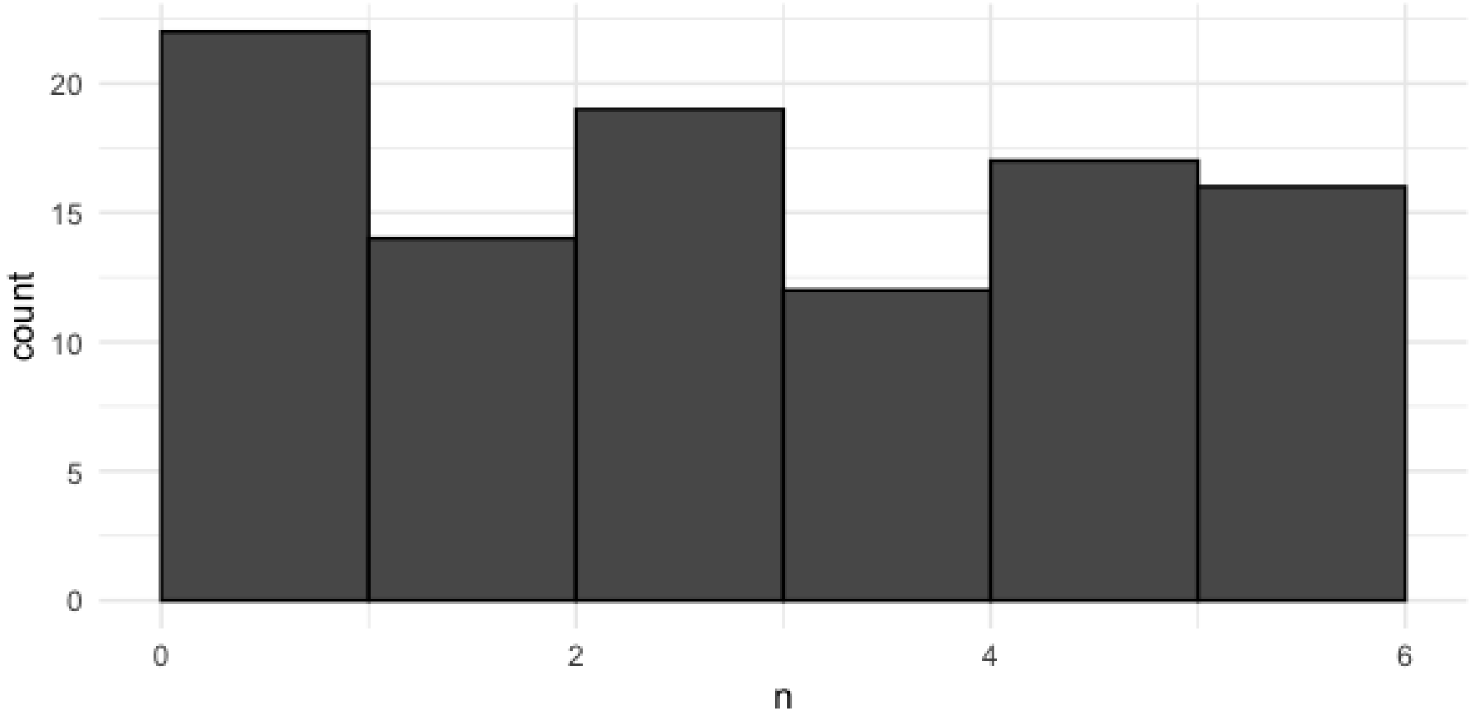
Theoretical probability distribution



`mean(die$n)` = `3.5`

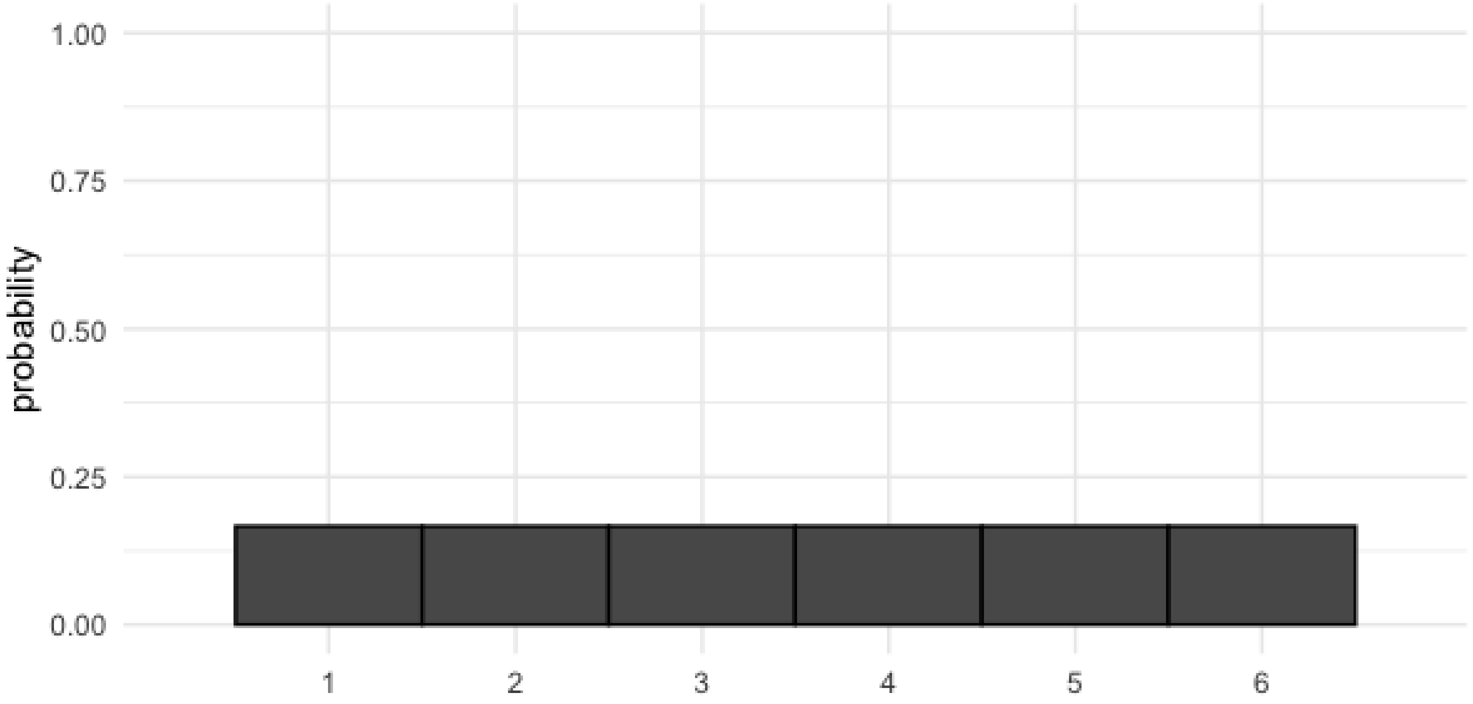
A bigger sample

Sample of 100 rolls



`mean(rolls_100$n)` = `3.36`

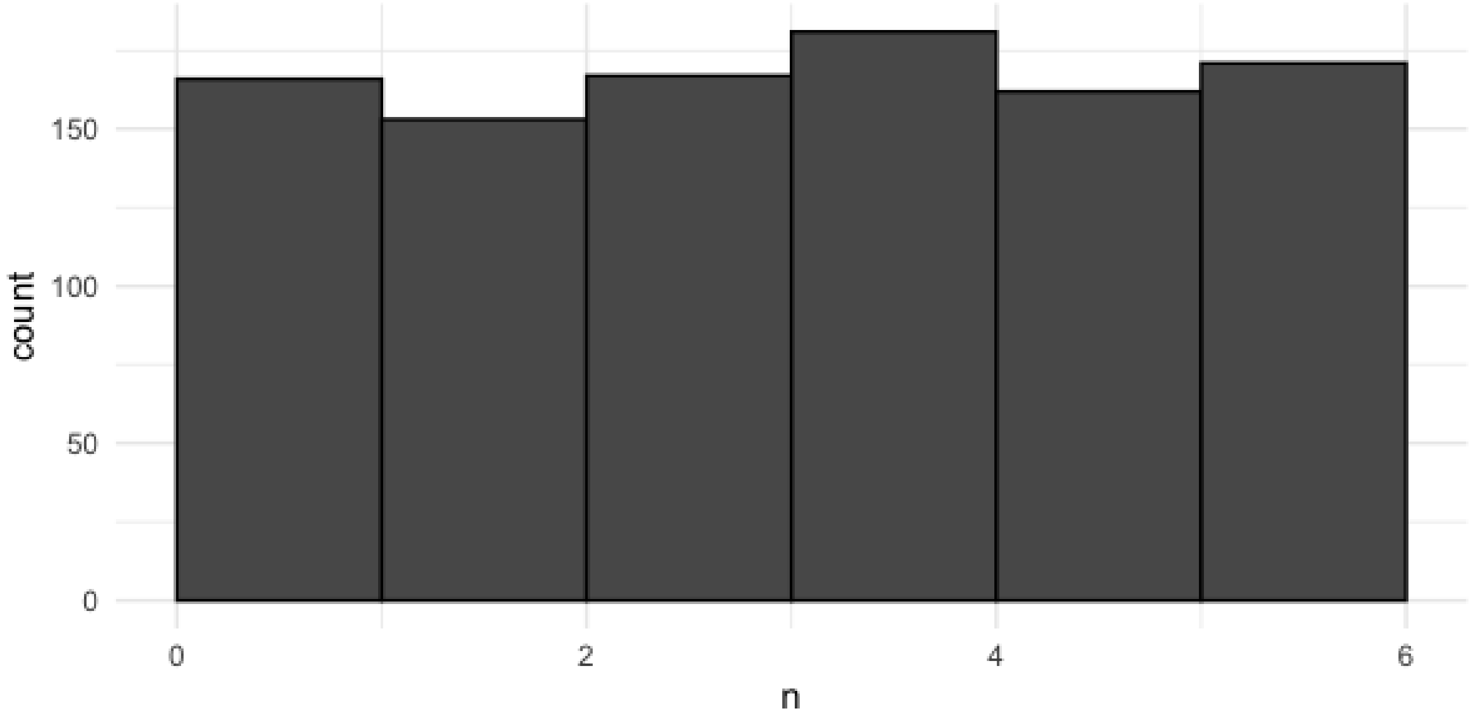
Theoretical probability distribution



`mean(die$n)` = `3.5`

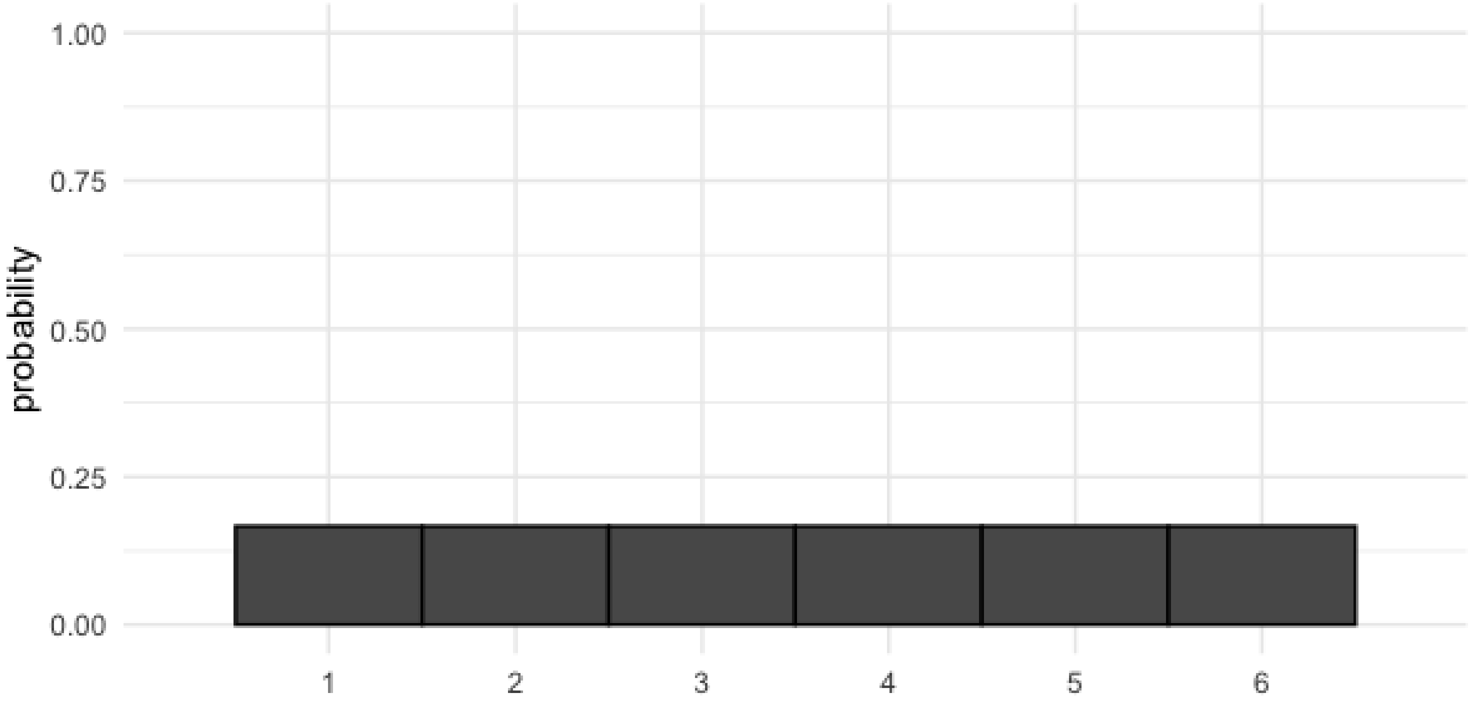
An even bigger sample

Sample of 1000 rolls



`mean(rolls_1000$n)` = `3.53`

Theoretical probability distribution



`mean(die$n)` = `3.5`

Law of large numbers

As the size of your sample increases, the sample mean will approach the expected value.

Sample size	Mean
10	3.00
100	3.36
1000	3.53

Let's practice!

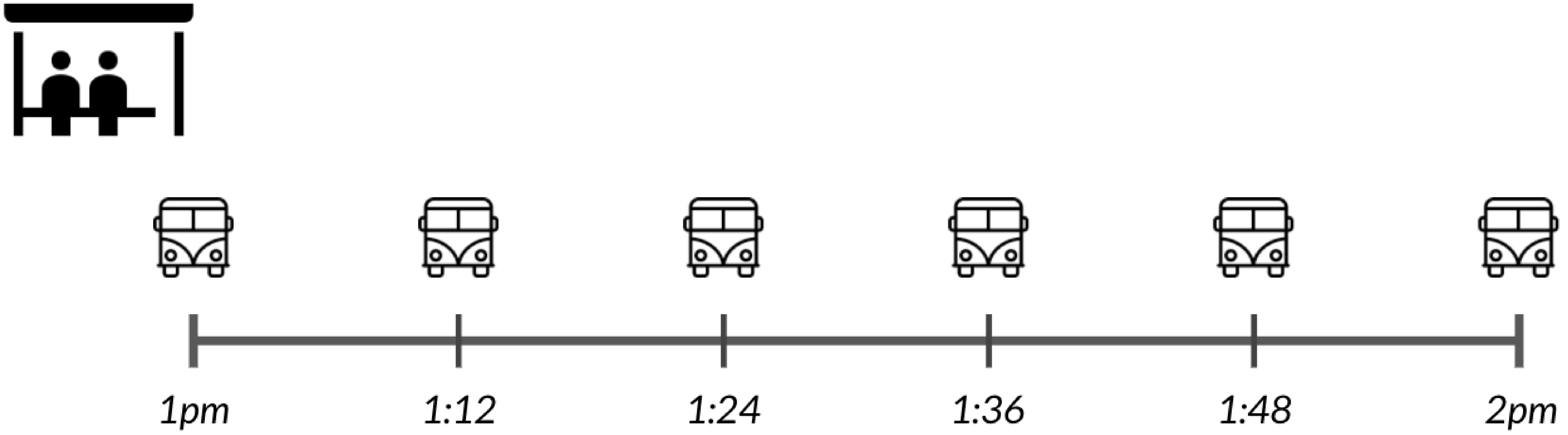
INTRODUCTION TO STATISTICS IN R

Continuous distributions

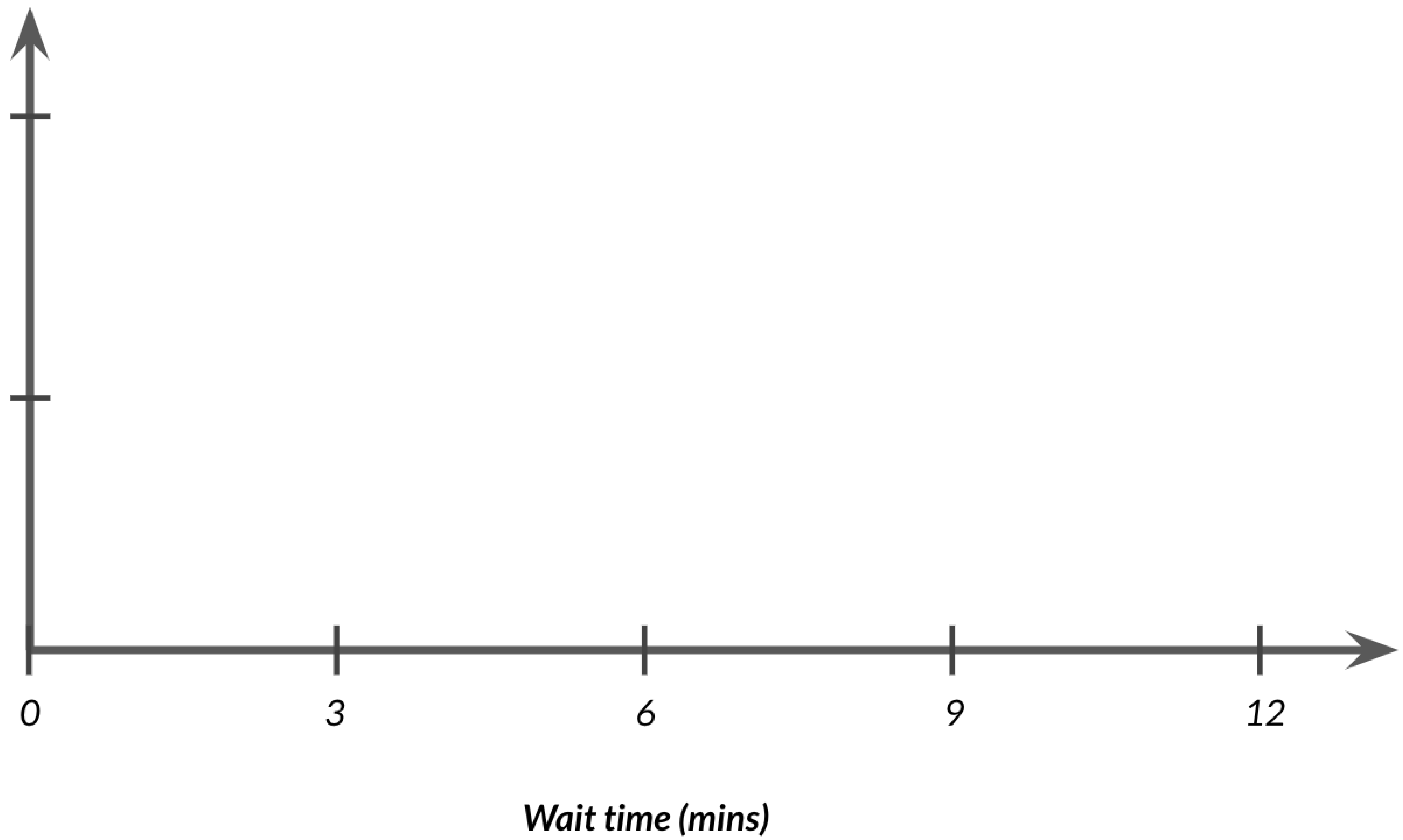
INTRODUCTION TO STATISTICS IN R

Maggie Matsui
Content Developer, DataCamp

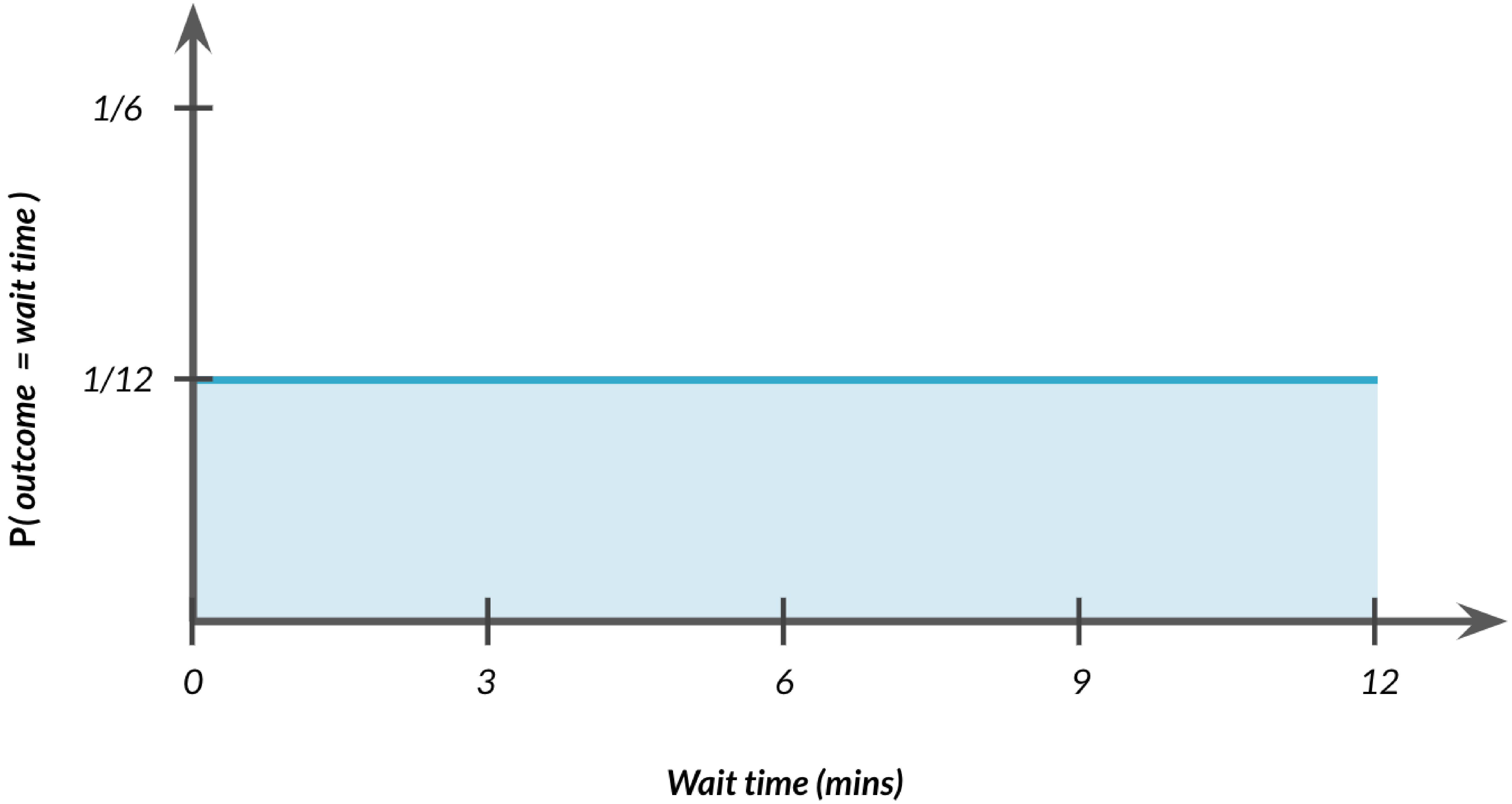
Waiting for the bus



Continuous uniform distribution

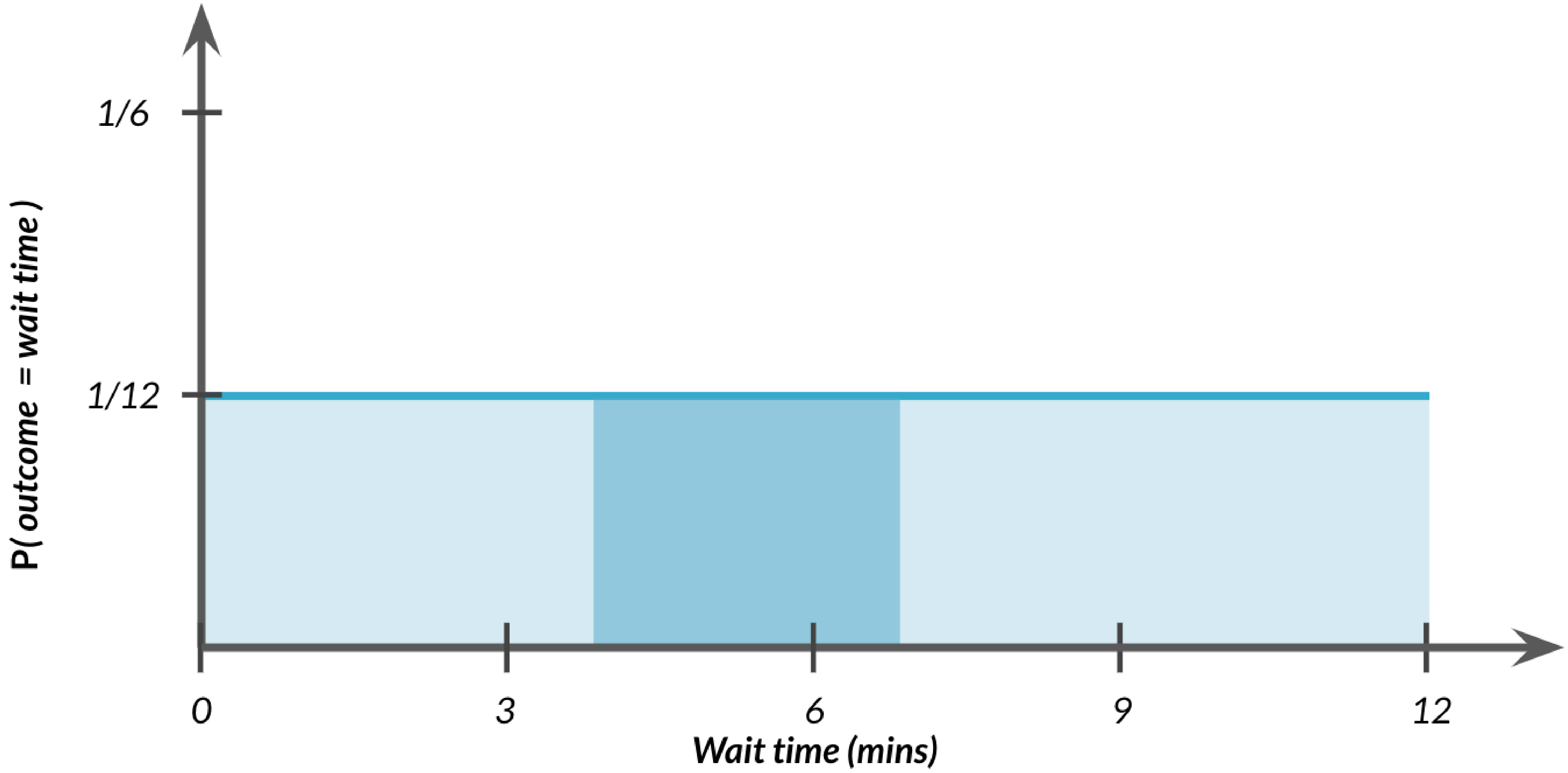


Continuous uniform distribution



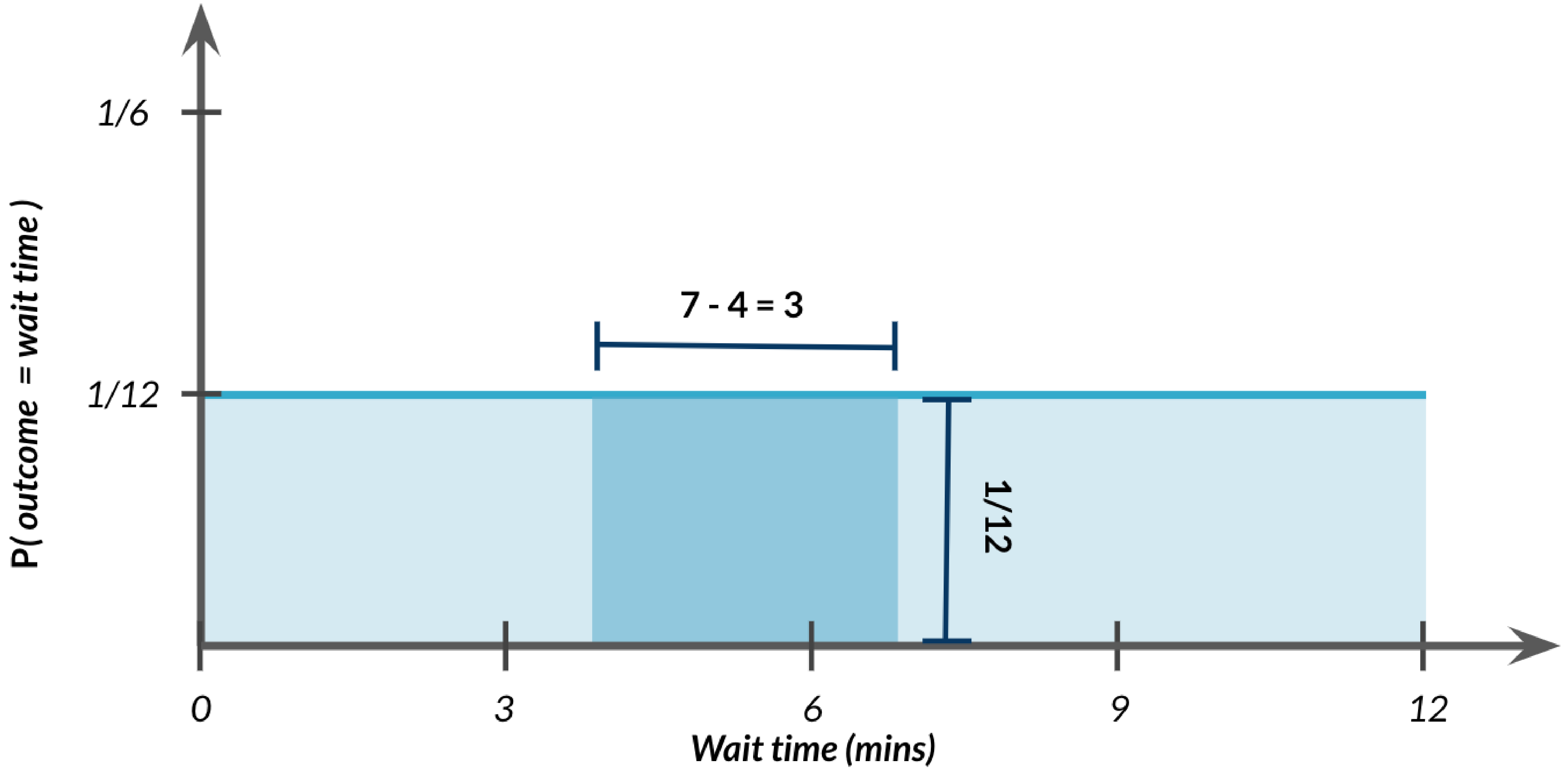
Probability still = area

$$P(4 \leq \text{wait time} \leq 7) = \ ?$$



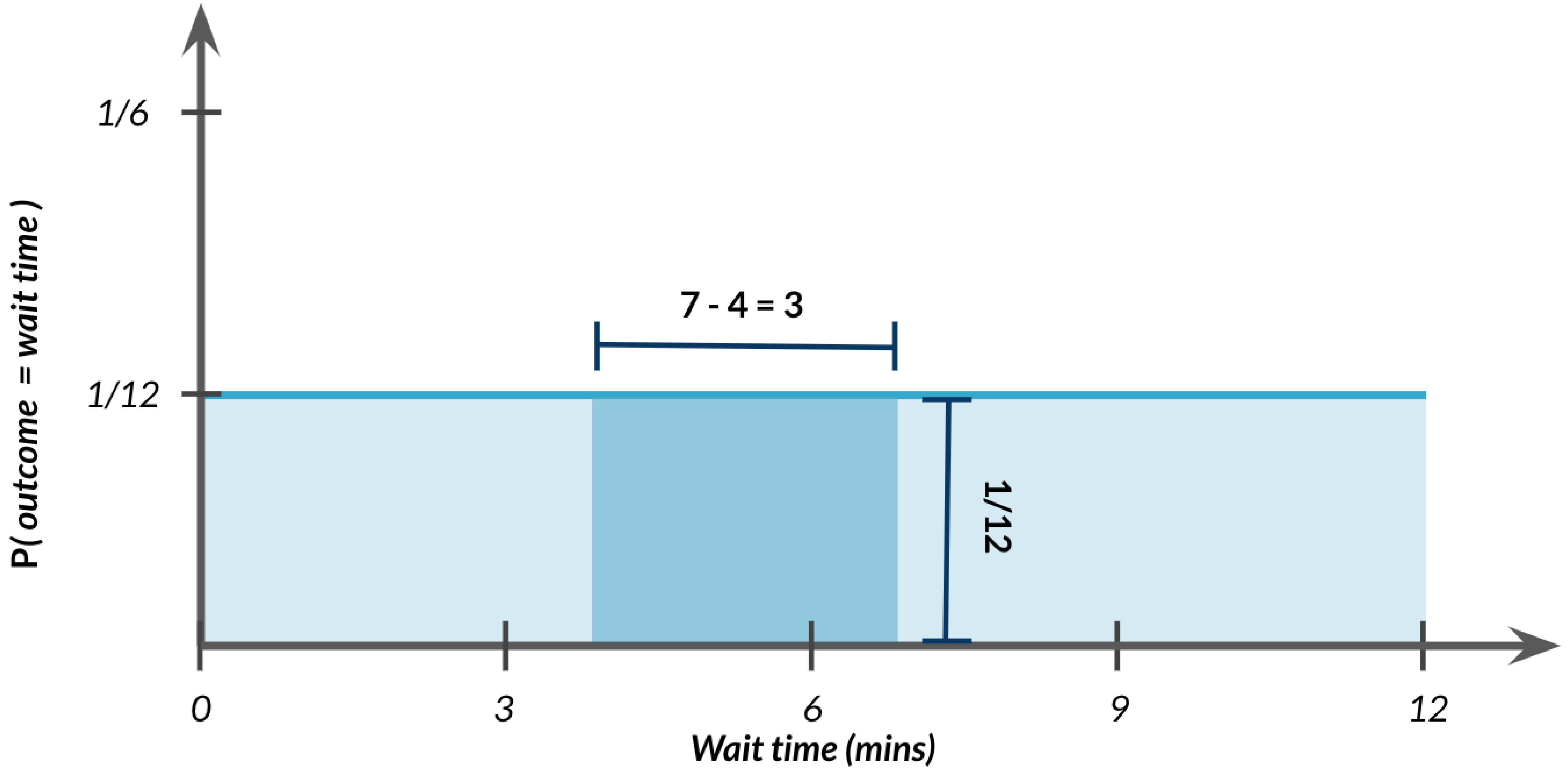
Probability still = area

$$P(4 \leq \text{wait time} \leq 7) = \ ?$$



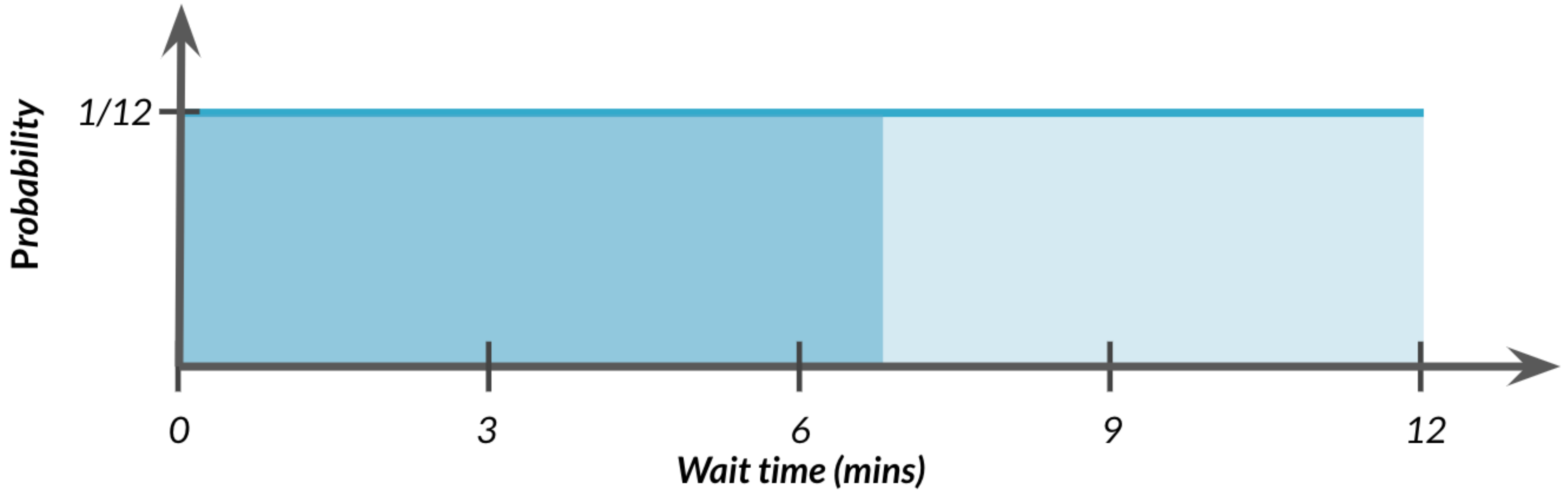
Probability still = area

$$P(4 \leq \text{wait time} \leq 7) = 3 \times 1/12 = 3/12$$



Uniform distribution in R

$$P(\text{wait time} \leq 7)$$

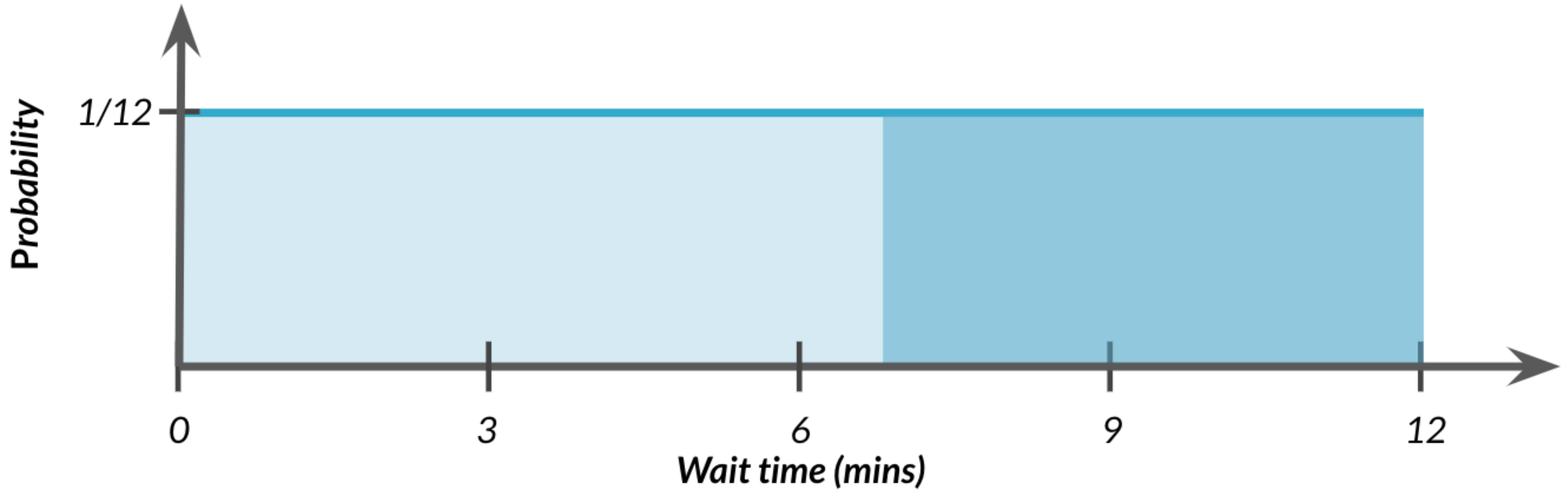



```
punif(7, min = 0, max = 12)
```

```
0.5833333
```

lower.tail

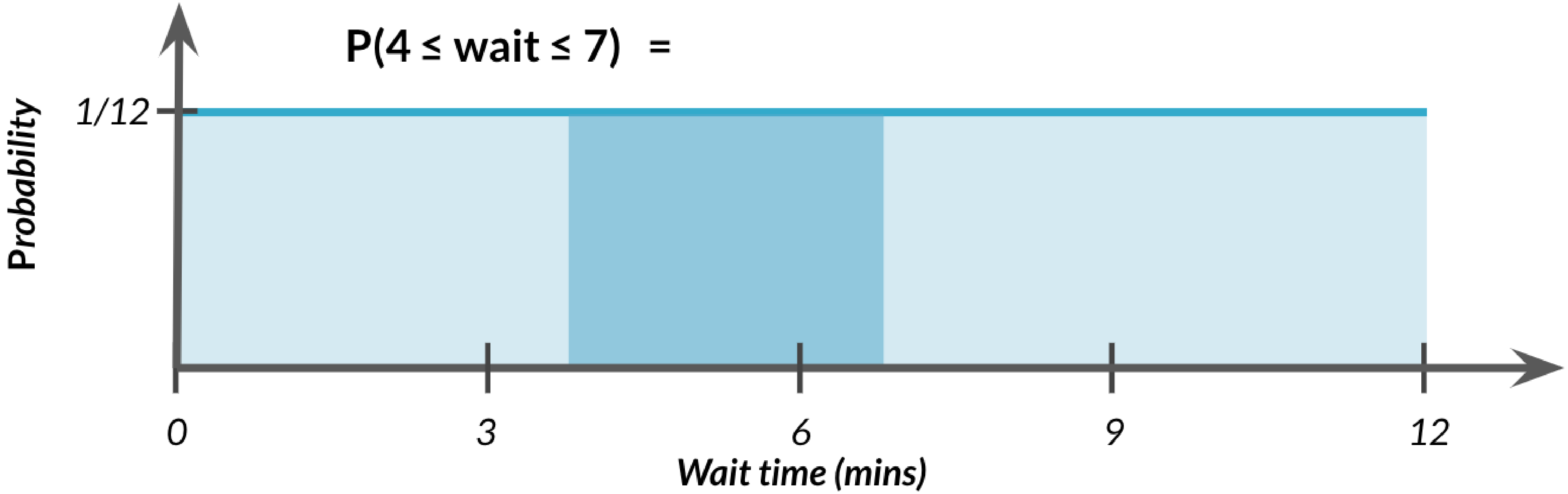
$$P(\text{wait time} \geq 7)$$



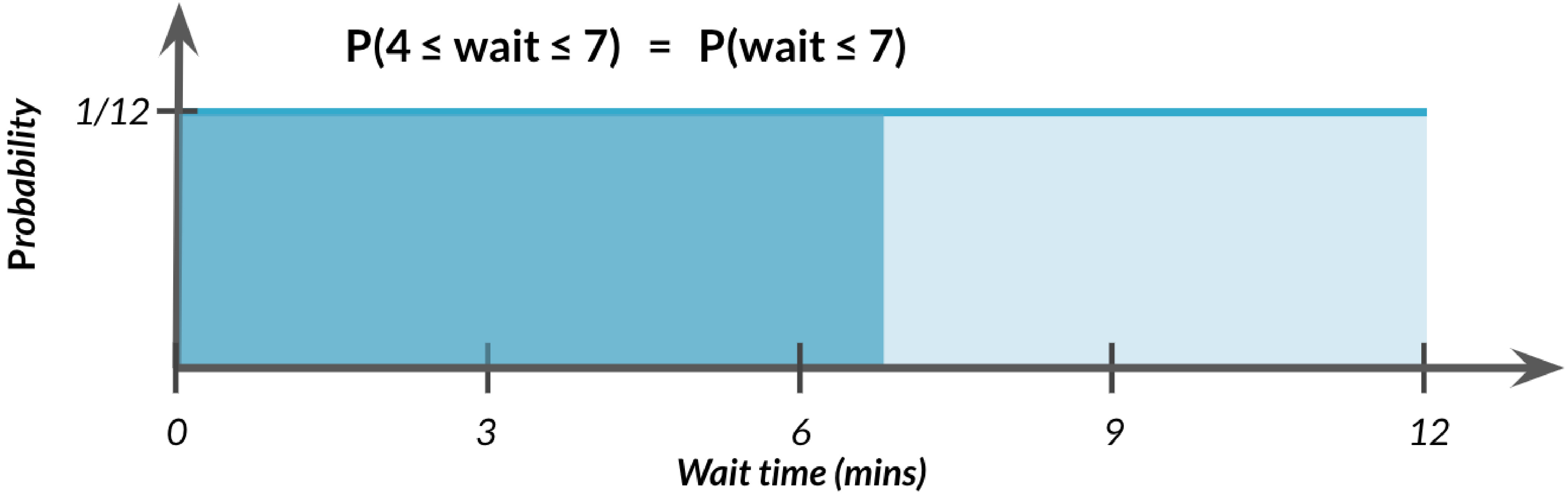

```
punif(7, min = 0, max = 12, lower.tail = FALSE)
```

```
0.4166667
```

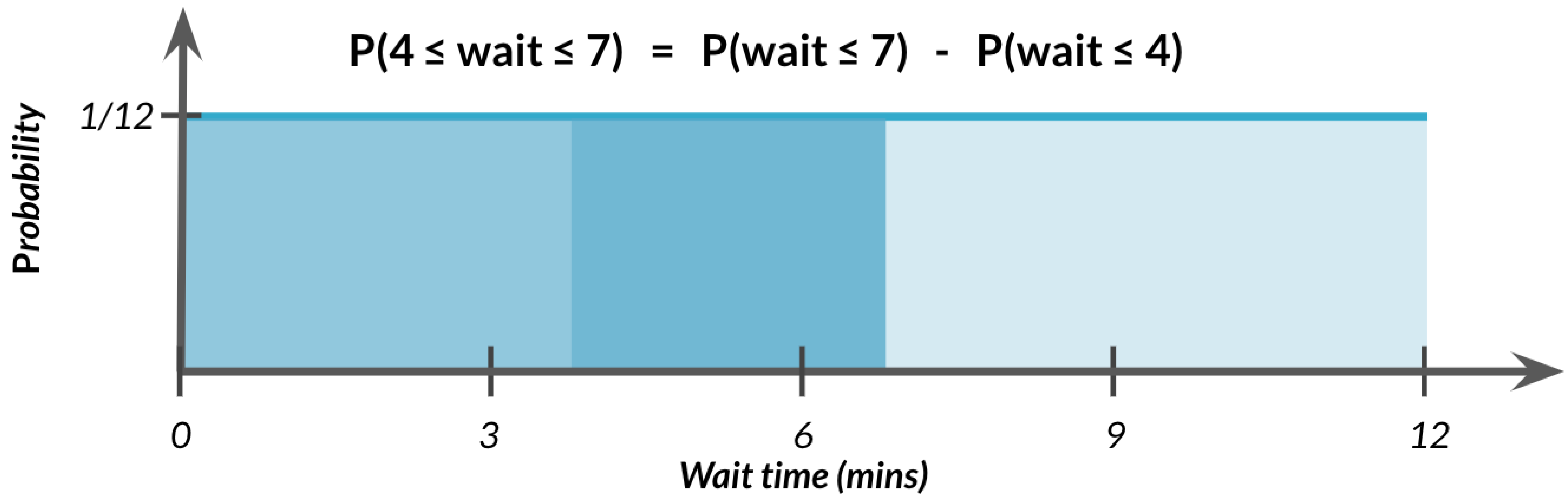
$$P(4 \leq \text{wait time} \leq 7)$$



$$P(4 \leq \text{wait time} \leq 7)$$



$$P(4 \leq \text{wait time} \leq 7)$$

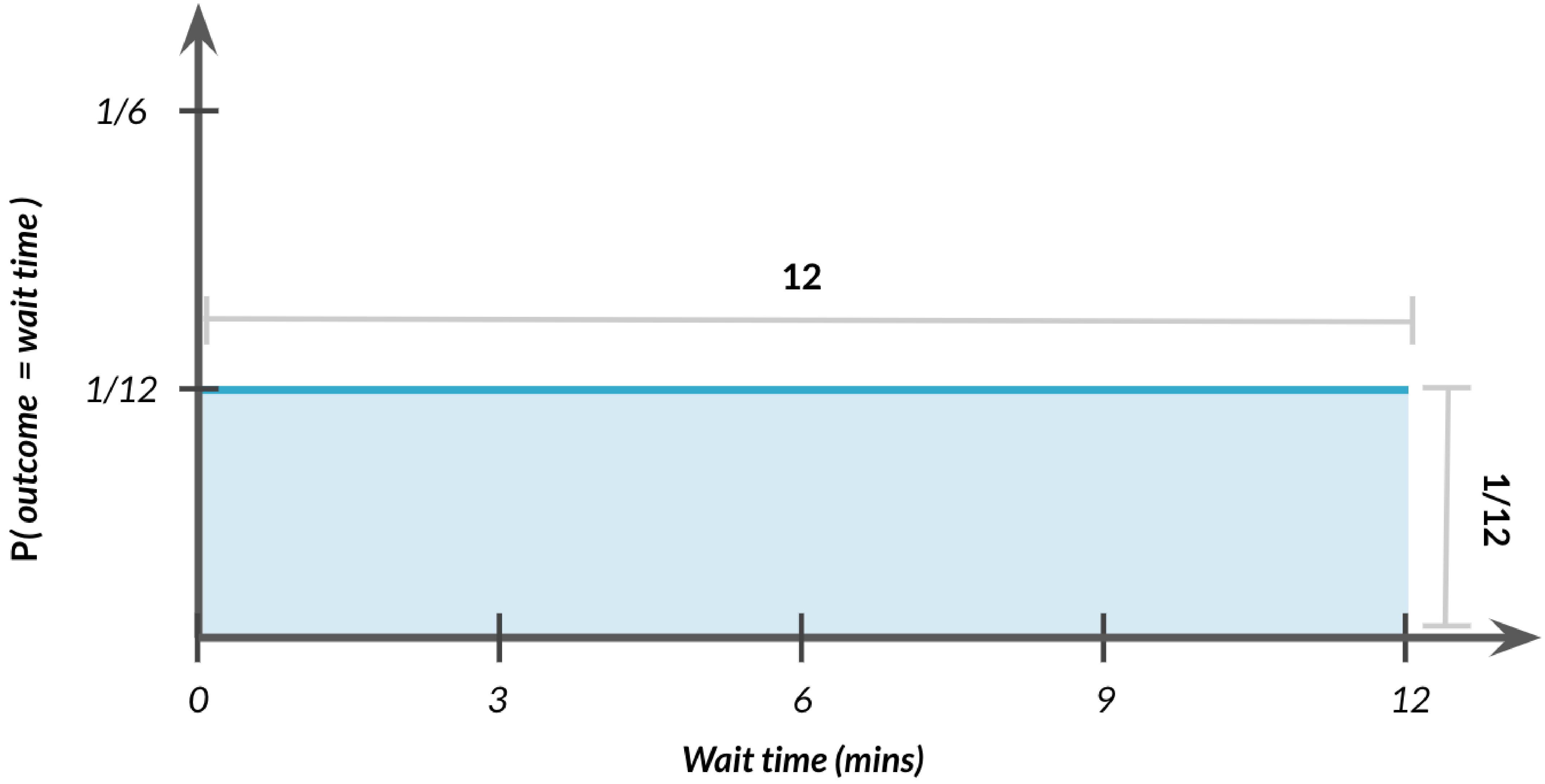



```r
punif(7, min = 0, max = 12) - punif(4, min = 0, max = 12)
```

```
0.25
```

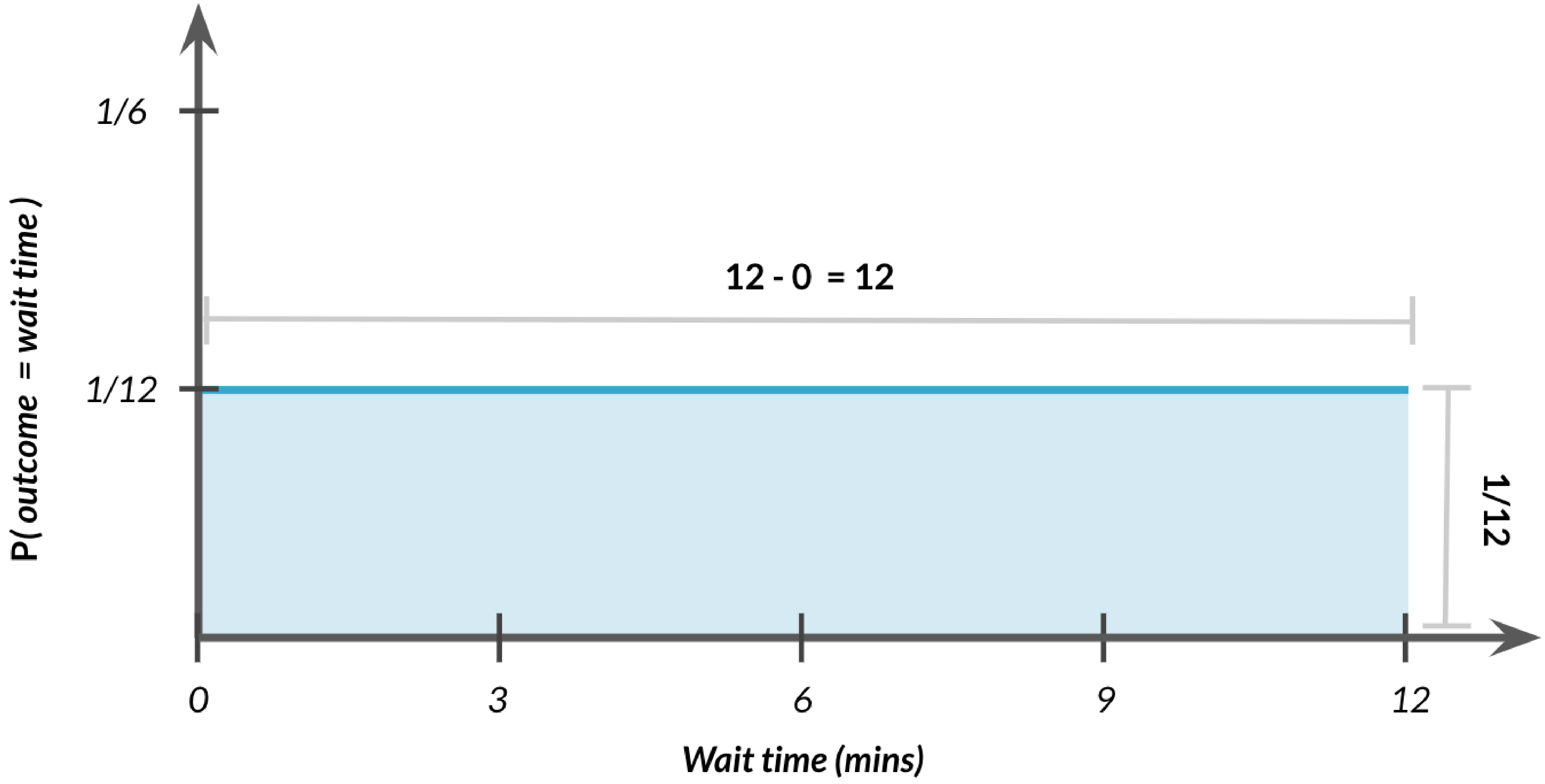
Total area = 1

$$P(0 \leq \text{wait time} \leq 12) = \ ?$$

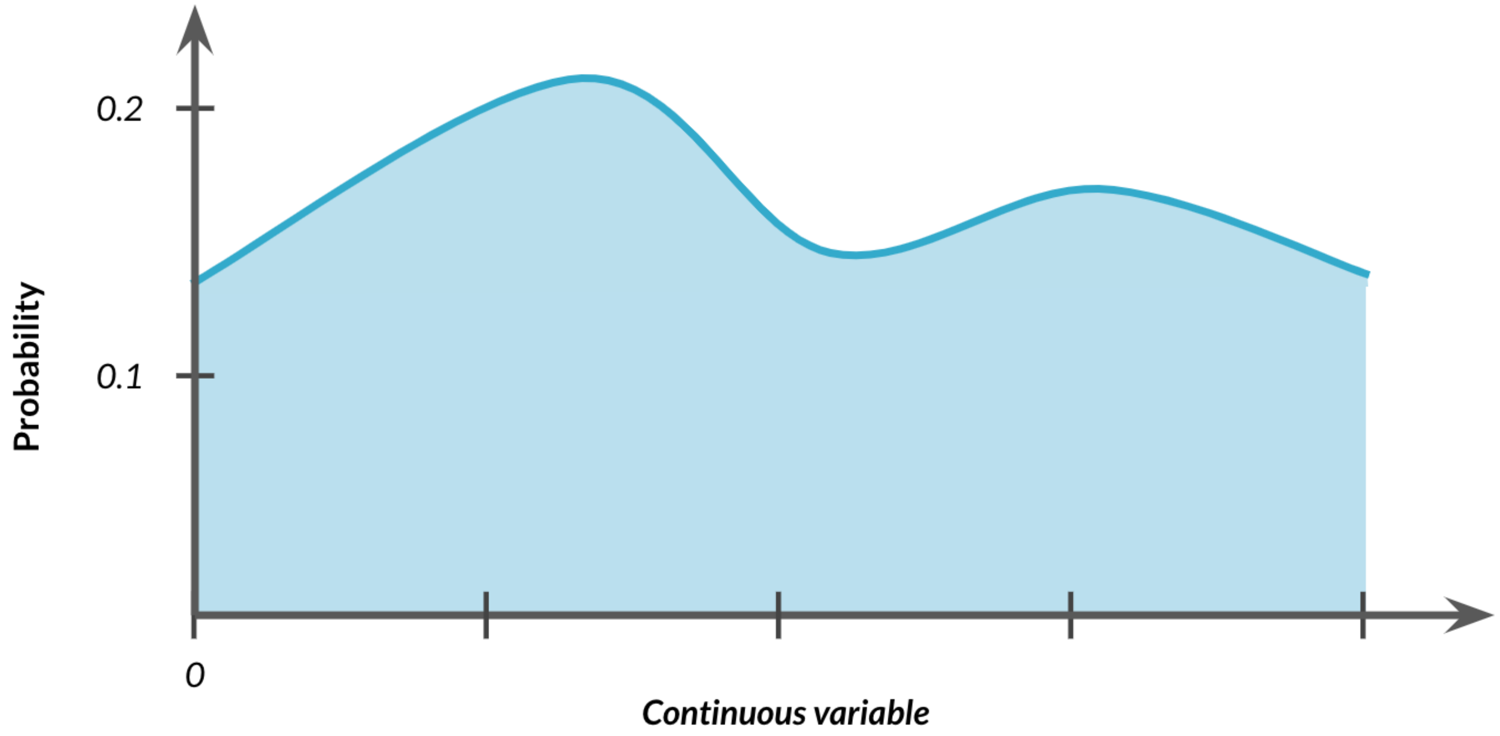


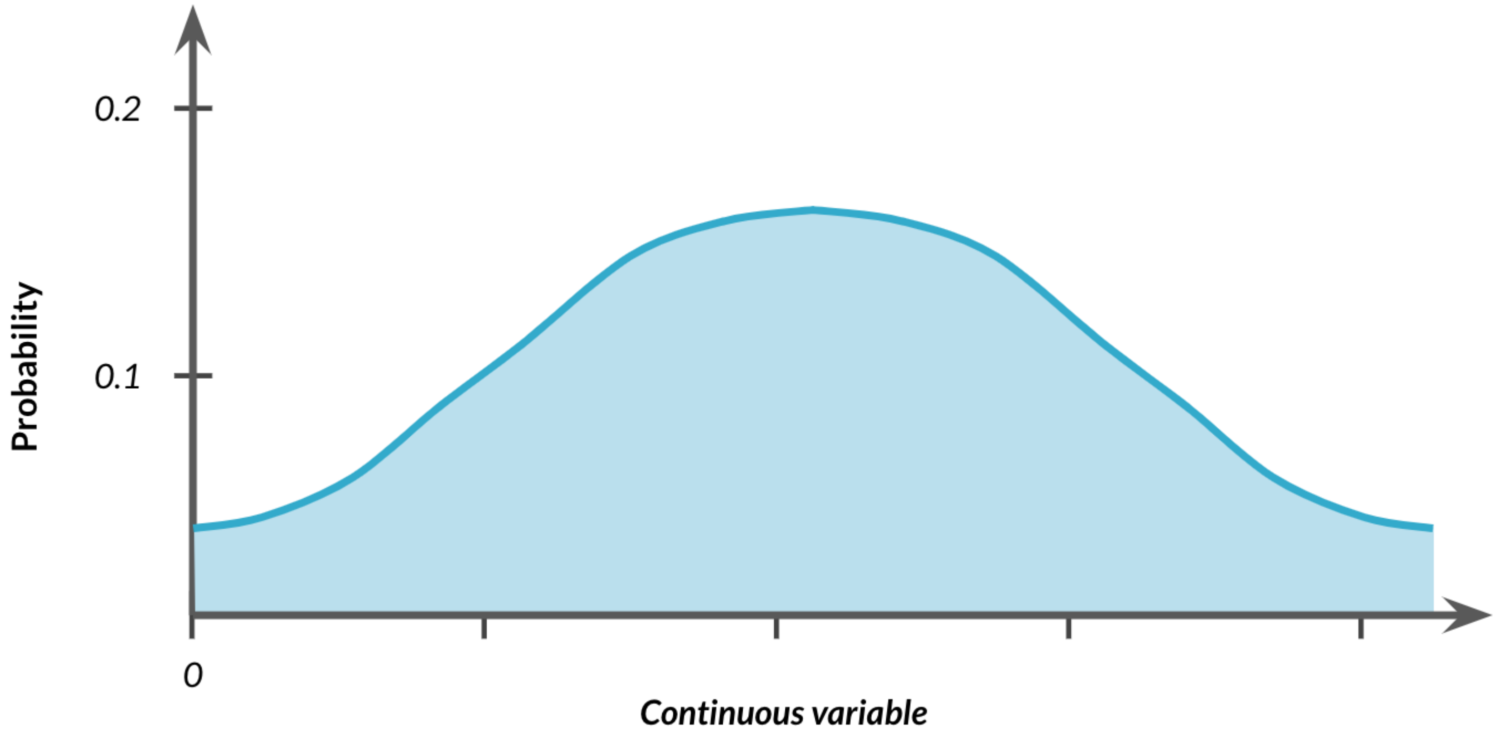
Total area = 1

$$P(0 \leq \text{outcome} \leq 12) = 12 \times 1/12 = 1$$

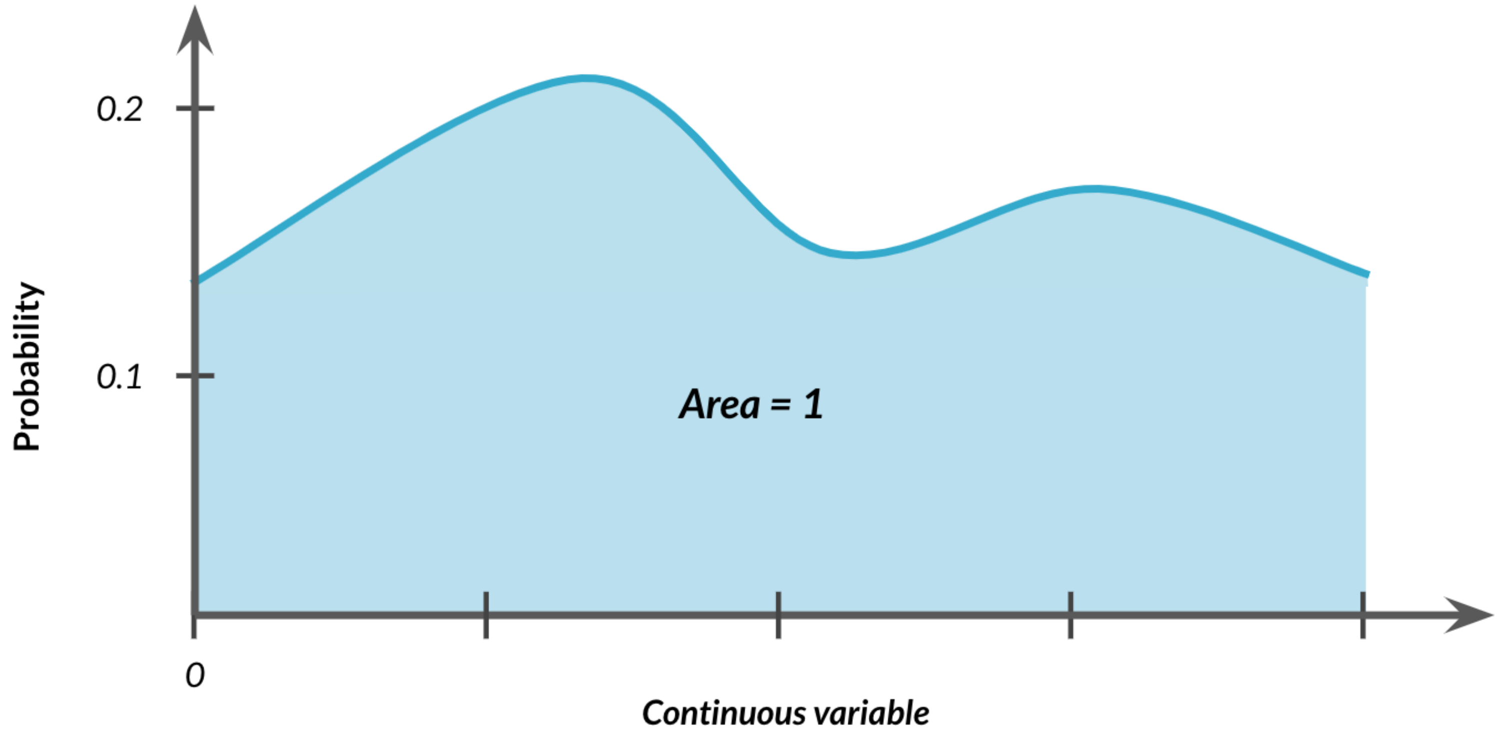


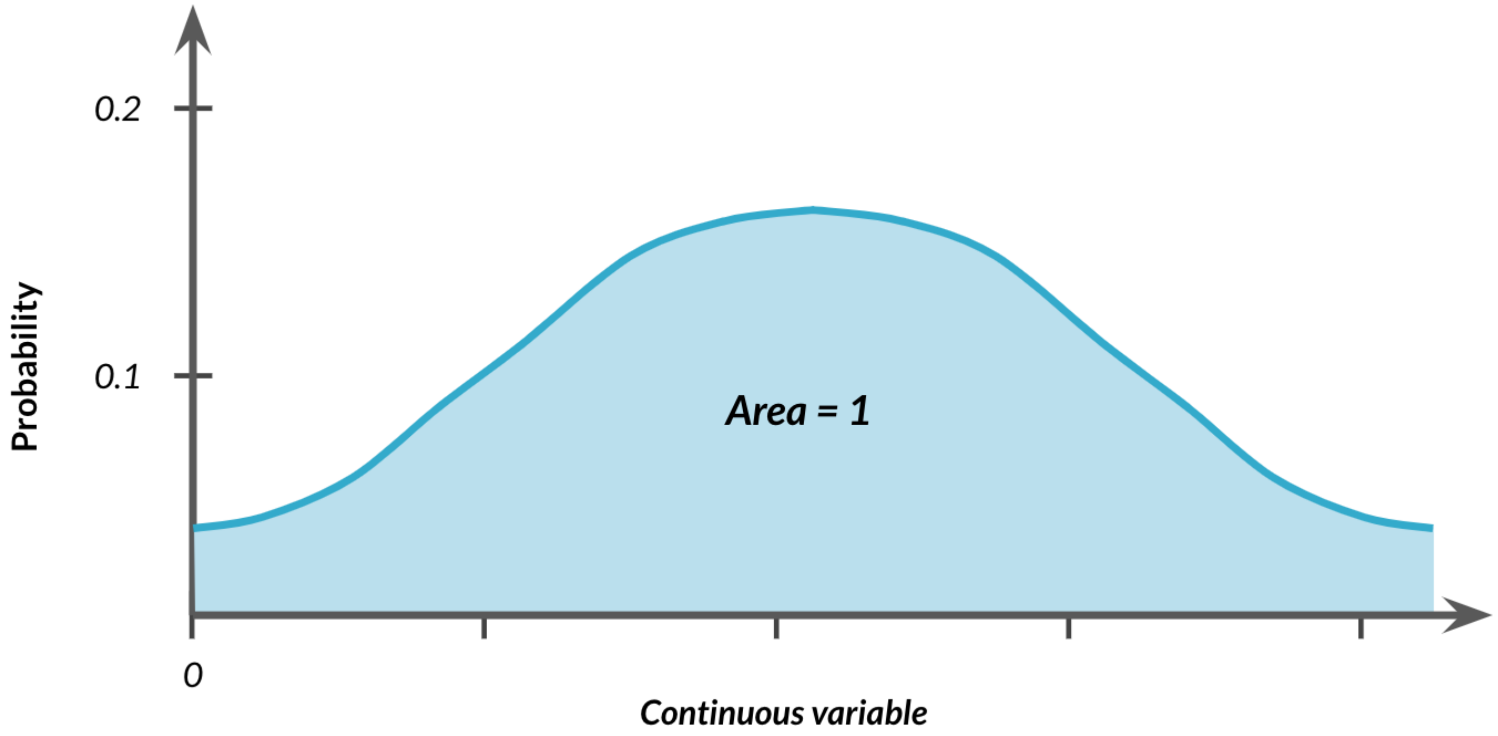
Other continuous distributions





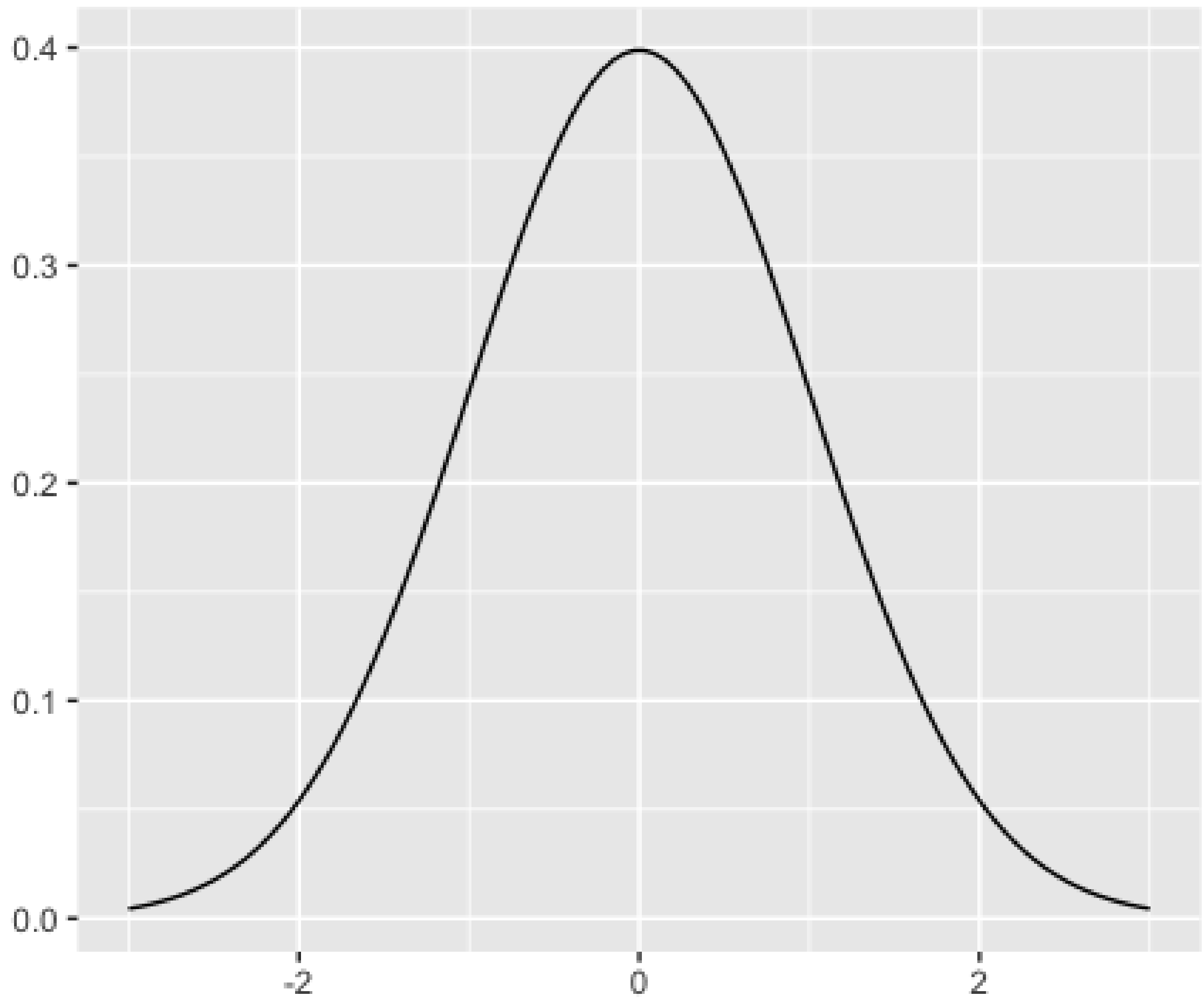
Other continuous distributions



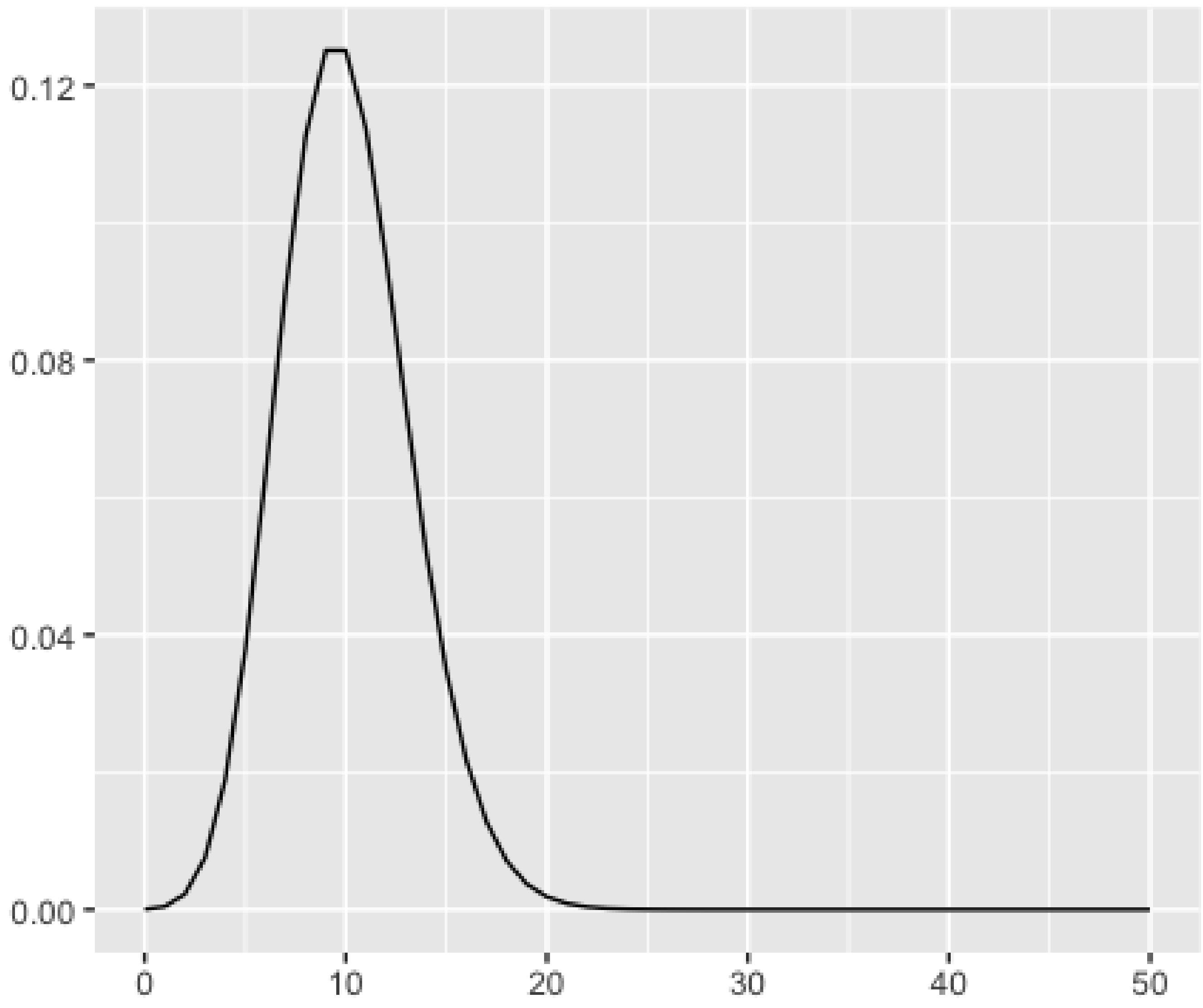


Other special types of distributions

Normal distribution



Poisson distribution



Let's practice!

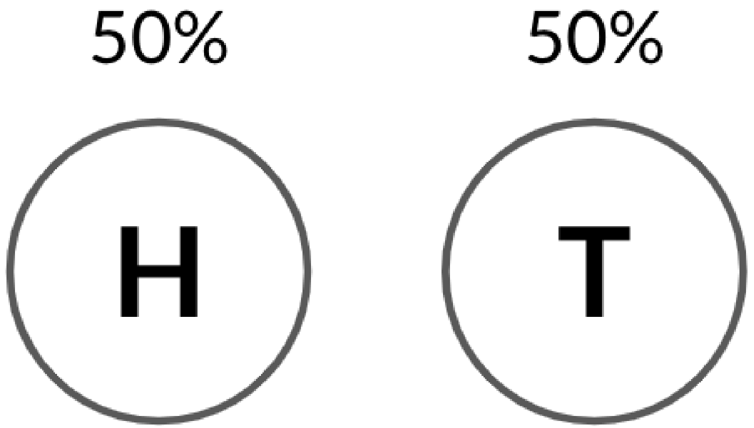
INTRODUCTION TO STATISTICS IN R

The binomial distribution

INTRODUCTION TO STATISTICS IN R

Maggie Matsui
Content Developer, DataCamp

Coin flipping



Binary outcomes

H	T
1	0
Success	Failure
Win	Loss

A single flip

`rbinom(# of trials, # of coins, # probability of heads/success)`

`1` = head, `0` = tails

```
rbinom(1, 1, 0.5)
```

```
1
```

```
rbinom(1, 1, 0.5)
```

```
0
```

One flip many times

```r
rbinom(8, 1, 0.5)
```

```
1 0 0 1 0 0 1 0
```

`rbinom(8, 1, 0.5)`

8 flips of 1 coin with 50% chance of success

Many flips one time

```
rbinom(1, 8, 0.5)
```

```
3
```

```
rbinom(1, 8, 0.5)
```

1 flip of 8 coins with 50% chance of success

Many flips many times

```
rbinom(10, 3, 0.5)
```

```
2 0 1 0 1 1 3 3 3 1
```

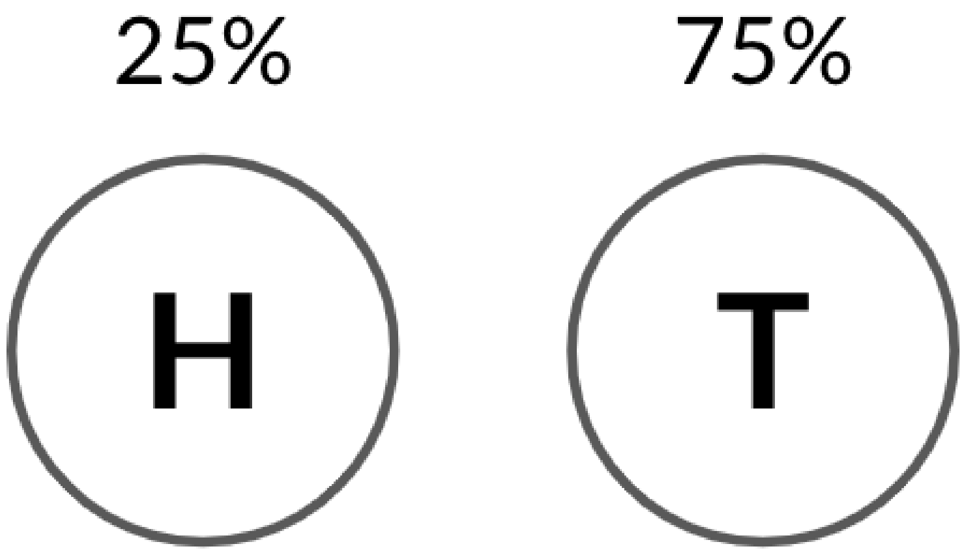
rbinom(10, 3, 0.5)

10 flips of 3 coins with 50% chance of success

Other probabilities

```
rbinom(10, 3, 0.25)
```

```
1 1 0 0 1 1 1 1 2 1
```



Binomial distribution

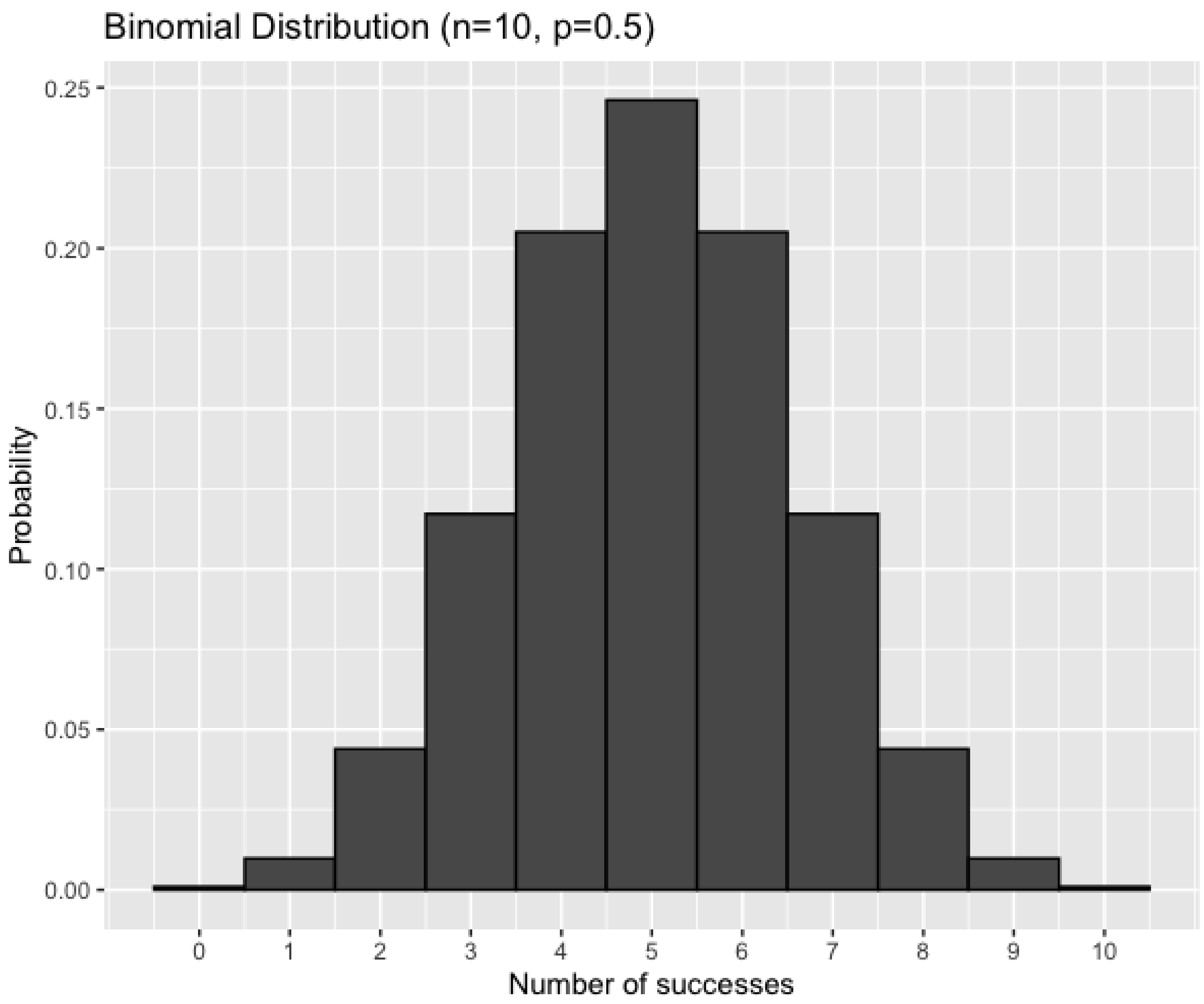
Probability distribution of the number of successes in a sequence of independent trials

E.g. Number of heads in a sequence of coin flips

Described by n and p

- n: total number of trials
- p: probability of success

```
          n    p
rbinom(3, 10, 0.5)
```



What's the probability of 7 heads?

$$P(\text{heads} = 7)$$

```
# dbinom(num heads, num trials, prob of heads)
dbinom(7, 10, 0.5)
```

```
0.1171875
```

What's the probability of 7 or fewer heads?

$P(\text{heads} \leq 7)$

```r
pbinom(7, 10, 0.5)
```

```
0.9453125
```

What's the probability of more than 7 heads?

$P(\text{heads} > 7)$

```
pbinom(7, 10, 0.5, lower.tail = FALSE)
```

```
0.0546875
```

```
1 - pbinom(7, 10, 0.5)
```

```
0.0546875
```

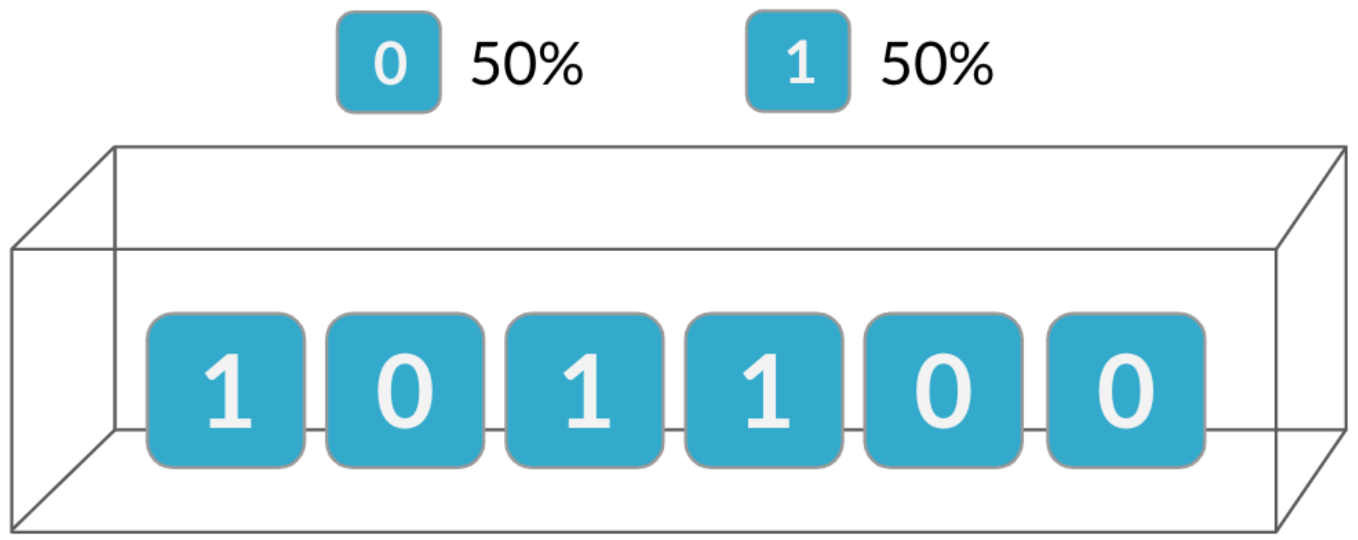
Expected value

$$\text{Expected value} = n \times p$$

$$\textit{Expected number of heads out of 10 flips} = 10 \times 0.5 = 5$$

Independence

*The binomial distribution is a probability distribution of the number of successes in a sequence of **independent** trials*



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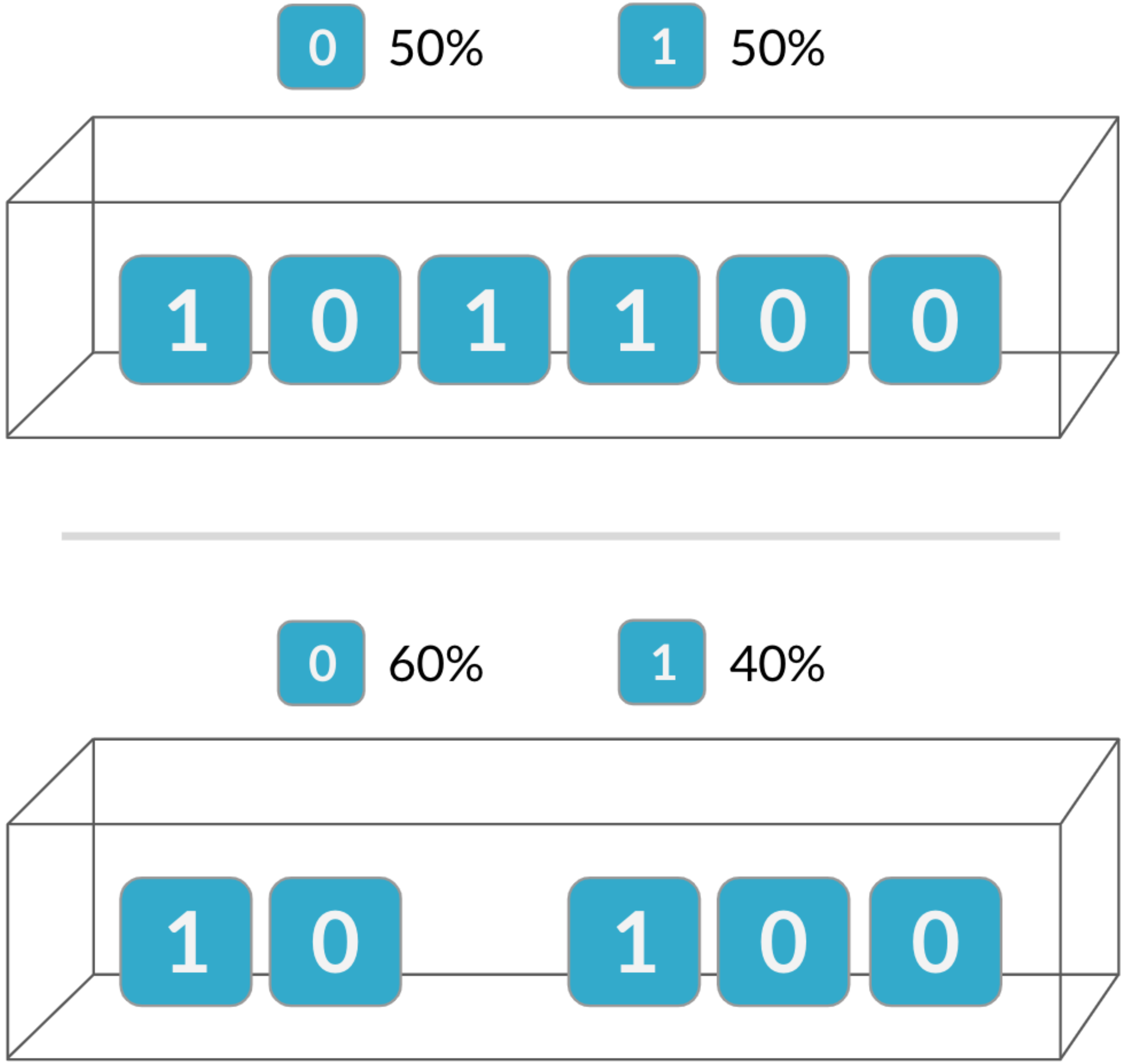

Probabilities of second trial are altered due to outcome of the first

If trials are not independent, the binomial distribution does not apply!

Let's practice!

INTRODUCTION TO STATISTICS IN R