Lecture 5: Chapter 5

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UAB Mathematics

15 June 15

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In this chapter, we combine the two methods! We use a statistical approach to estimate parameters used in a probabilistic approach.

Definition (Random Variable)

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Definition (Continuous vs. Discrete Random Variables)

A discrete random variable can take on a value from a finite or countably infinite collection of values whereas a **continuous** random variable can take on a value from a collection of uncountably infinite values.

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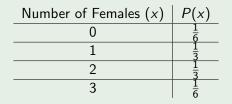
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Example (Probability of Having x Females in a Biological Family with Three Children)

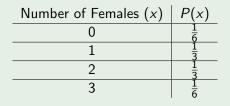
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You can graph a probability distribution of a discrete random variable as a histogram. What would the probability histogram look like for this distribution?

Mean, Variance, and Standard Deviation

Definition (Mean)

$$\mu = \sum_{i=1}^{n} [x_i \cdot P(x_i)]$$

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Mean, Variance, and Standard Deviation

Definition (Mean)

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The mean is the "expected value" of the random variable x. We write this as $E = \mu$.

Definition (Variance)

$$\sigma^{2} = \sum_{i=1}^{n} [(x_{i} - \mu)^{2} \cdot P(x_{i})] = \sum_{i=1}^{n} [x_{i}^{2} \cdot P(x_{i})] - \mu^{2}$$

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Definition (Standard Deviation)

$$\sigma = \sqrt{\sum_{i=1}^{n} [x_i^2 \cdot P(x_i)] - \mu^2}$$

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Number of Females (x)	P(x)	$x \cdot P(x)$
0	$\frac{1}{6}$	0
1	$\frac{1}{3}$	0.333
2	$\frac{1}{3}$	0.666
3	$\frac{1}{6}$	0.5
		$\sum x_i \cdot P(x_i)$

Let's calculate $\mu,\,\sigma^2,\,{\rm and}\,\,\sigma$ for our previous example.

Number of Females (x)	P(x)	$x \cdot P(x)$
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1	$\frac{1}{3}$	0.333
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3	$\frac{1}{6}$	0.5
		$\sum x_i \cdot P(x_i) = 1.5 = \mu$

# of Females (x)	P(x)	x_i^2	$x_i^2 \cdot P(x_i)$
0	$\frac{1}{6}$	0	0
1	$\frac{1}{3}$	1	0.333
2	$\frac{1}{3}$	4	1.333
3	$\frac{1}{6}$	9	1.5
			$\sum x_i^2 \cdot P(x_i) - \mu^2$

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3	$\frac{1}{6}$	9	1.5
			$\sum x_i^2 \cdot P(x_i) - \mu^2 = 0.9166 = \sigma^2$

Thus, $\sigma = 0.9574$.

We can construct ranges for usual values using these calculated means and standard deviations as well.

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We may also determine if a value is unusually high or low by using the 5% rule:

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• A value X is unusually low if $P(x \le X) \le 0.05$.

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- A value X is unusually low if $P(x \le X) \le 0.05$.
- A value X is unusually high if $P(x \ge X) \le 0.05$.

A probability distribution is a **binomial probability distribution** if the following criteria are met:

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 often called "success" and "failure".

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- The procedure has a fixed number of trials *n*.
- The trials are independent.
- The results of the trial must have only two possible outcomes
 often called "success" and "failure".
- The probability for success must remain the same throughout all trials.

Let's investigate our example of the number of females in a 3-children family.

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What's the probability P(x = 1)? That would be the probability of having one female: FMM, MFM, MMF.

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So
$$P(x = 0) = \frac{1}{8}$$
, $P(x = 1) = \frac{3}{8}$, $P(x = 2) = \frac{3}{8}$, $P(x = 3) = \frac{1}{8}$.

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Here, $\binom{n}{K}$ (read *n* choose *K*) simply denotes $\frac{n!}{(n-K)!K!}$.



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Can this even be modeled by a binomial distribution?



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Example

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Can this even be modeled by a binomial distribution? Strictly speaking, it can't. Why? But we can approximate a selection of 20 students without replacement as independent because the 20 students selected represent less than 5% of the population under consideration. So,

$$P(x=5) = \binom{20}{5} (0.2)^5 (0.8)^{20-5} = 15504(0.2)^5 (0.8)^{15} \approx 0.175.$$



At Arlington High School, 20% of the student body of 1200 students is in walking distance to class. We you randomly select 20 students (without replacement) from the 1200, what is the probability that exactly 10 or more of them will live in walking distance to school?



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In this case, we would say that 10 is an unusually high number of successes.

Example: Binomial(15,0.25)

Use StatCrunch to determine

■ *P*(*x* > 4)



Example: Binomial(15,0.25)

Use StatCrunch to determine

• $P(x > 4) \approx 0.314$.



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- $P(x > 4) \approx 0.314$.
- $P(x = 2) \approx 0.156.$
- $P(x \ge 7)$

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•
$$P(x > 4) \approx 0.314$$
.

$$P(x=2)\approx 0.156.$$

•
$$P(x \ge 7) \approx 0.057.$$

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• $P(x \leq 0)$

•
$$P(x > 4) \approx 0.314$$
.

•
$$P(x = 2) \approx 0.156.$$

•
$$P(x \ge 7) \approx 0.057$$
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•
$$P(x \leq 0) \approx 0.013$$
.

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$$\sigma = \sqrt{npq}$$

With this information, we could use the range rule of thumb rather than the 5% rule of thumb to determine if a value is typical or not.

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$$[3.75 - 2(1.667), 3.75 + 2(1.667)] = [0.396, 7.104].$$

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Because we know the values only take whole numbers, we say that the range of typical values are the whole numbers from 1 to 7.