

How to read the Binomial Distribution Table

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The Binomial Distribution Table is an essential tool in statistics and probability theory, designed to simplify the calculation of probabilities associated with discrete events. Specifically, it allows researchers and analysts to quickly determine the likelihood of a specific number of successes occurring in a fixed sequence of independent trials.

While the binomial probability formula, $P(X=k) = C(n, k) * p^k * (1-p)^{(n-k)}$, provides the exact calculation, the table offers a pre-computed resource. Historically, before powerful computing became universally available, these tables were indispensable for avoiding complex arithmetic, especially when dealing with large sample sizes or calculating cumulative probability.

Understanding how to navigate this resource is critical. The standard structure of a Binomial Distribution Table usually presents the number of trials (n) along one axis and the probability of success (p) along the other. The intersection of these parameters yields the probability value, which often represents the cumulative probability--that is, the probability of obtaining that number of successes or fewer ($P(X \leq r)$) out of the total number of trials.

Prerequisites: The Assumptions and Parameters of the Model

Before attempting to use the Binomial Distribution Table, one must confirm that the underlying situation meets the four essential criteria for a binomial experiment. These criteria ensure that the resulting probabilities derived from the table are statistically valid and applicable to the problem at hand.

The experiment consists of a fixed number of trials, denoted by n .

Each trial must be independent; the outcome of one trial cannot influence the outcome of any subsequent trial.

Each trial results in only two possible outcomes, conventionally labeled as "success" or "failure."

The probability of success, p , remains constant from trial to trial.

Once these assumptions are verified, the table requires three fundamental parameters for effective use. These parameters define the specific scenario for which you are seeking the probability.

n : This represents the total number of independent trials conducted in the experiment. For example, if you flip a coin 10 times, $n = 10$.

r (or X): This is the specific number of "successes" we are interested in observing within the n trials. This value is often referred to as k in formulaic notation, but r is commonly used in table references.

p : This is the probability of success occurring on any single trial. It must be a fixed value between 0 and 1.

By successfully locating the intersection corresponding to your specific n , the desired number of

successes r , and the probability p , you can extract the required probability value, whether it is for an exact outcome or a cumulative range.

Differentiating Cumulative vs. Individual Tables

It is crucial to recognize that not all binomial tables are structured identically. Most modern statistical tables provide the cumulative probability function (CDF), denoted $P(X \leq r)$. However, some older texts or specific academic resources may provide the individual probability mass function (PMF), $P(X = r)$.

If you are using a cumulative table, the value at the intersection represents the probability of observing r **successes or fewer**. To find the probability of exactly r successes using a cumulative table, you must employ subtraction: $P(X = r) = P(X \leq r) - P(X \leq r - 1)$. This conversion method is fundamental for accuracy when dealing with cumulative data.

Conversely, tables listing individual probabilities (PMF) simplify the task of finding $P(X=r)$ but require addition when calculating cumulative sums (e.g., $P(X \leq 4)$). Always check the table's header or introductory notes to confirm whether it lists individual or cumulative probability values, as misinterpreting this detail is the most common source of error when working with binomial tables.

Navigating the Table Structure

Reading the binomial table involves a systematic three-step lookup process. First, locate the correct section corresponding to the total number of trials, n . Tables are often segmented by n value. Second, identify the column corresponding to the probability of success, p . These values typically run along the top header row of the table.

The third and final step involves locating the row corresponding to the number of successes of interest, r . These values usually start at 0 and run vertically down the left margin. The cell where the row (r) and the column (p) intersect provides the desired probability value. If the table is cumulative, this value is $P(X \leq r)$.

It is important to note that due to symmetry, if the probability of success p exceeds 0.5, some tables may require you to calculate the probability of failure ($q = 1 - p$) and look up the corresponding number of failures instead of successes, especially if the table is limited. The examples provided below focus on direct lookup based on p and r , utilizing a table that provides individual probabilities $P(X = r)$.

Example 1: Finding an Exact Probability (P(X = r))

Question: Jessica is a basketball player who makes 60% of her free-throw attempts. If she shoots 6 free throws, what is the probability that she makes **exactly 4**?

This scenario perfectly fits the binomial model where:

n (total trials) = 6

r (exact successes) = 4

p (probability of success) = 0.60

To answer this question, we must look up the value in the binomial distribution table that corresponds to these parameters. We locate the section for n = 6. We then move along the header row to find the column for p = 0.60, and finally, we move down that column to the row corresponding to r = 4.

The image below highlights the necessary intersection point:

n	r	p															
		.01	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75
2	0	.980	.902	.810	.723	.640	.563	.490	.423	.360	.303	.250	.203	.160	.123	.090	.063
	1	.020	.095	.180	.255	.320	.375	.420	.455	.480	.495	.500	.495	.480	.455	.420	.375
	2	.000	.002	.010	.023	.040	.063	.090	.123	.160	.203	.250	.303	.360	.423	.490	.563
3	0	.970	.857	.729	.614	.512	.422	.343	.275	.216	.166	.125	.091	.064	.043	.027	.016
	1	.029	.135	.243	.325	.384	.422	.441	.444	.432	.408	.375	.334	.288	.239	.189	.141
	2	.000	.007	.027	.057	.096	.141	.189	.239	.288	.334	.375	.408	.432	.444	.441	.422
	3	.000	.000	.001	.003	.008	.016	.027	.043	.064	.091	.125	.166	.216	.275	.343	.422
4	0	.961	.815	.656	.522	.410	.316	.240	.179	.130	.092	.062	.041	.026	.015	.008	.004
	1	.039	.171	.292	.368	.410	.422	.412	.384	.346	.300	.250	.200	.154	.112	.076	.047
	2	.001	.014	.049	.098	.154	.211	.265	.311	.346	.368	.375	.368	.346	.311	.265	.211
	3	.000	.000	.004	.011	.026	.047	.076	.112	.154	.200	.250	.300	.346	.384	.412	.422
	4	.000	.000	.000	.001	.002	.004	.008	.015	.026	.041	.062	.092	.130	.179	.240	.316
5	0	.951	.774	.590	.444	.328	.237	.168	.116	.078	.050	.031	.019	.010	.005	.002	.001
	1	.048	.204	.328	.392	.410	.396	.360	.312	.259	.206	.156	.113	.077	.049	.028	.015
	2	.001	.021	.073	.138	.205	.264	.309	.336	.346	.337	.312	.276	.230	.181	.132	.088
	3	.000	.001	.008	.024	.051	.088	.132	.181	.230	.276	.312	.337	.346	.336	.309	.264
	4	.000	.000	.000	.002	.006	.015	.028	.049	.077	.113	.156	.206	.259	.312	.360	.396
	5	.000	.000	.000	.000	.000	.001	.002	.005	.010	.019	.031	.050	.078	.116	.168	.237
6	0	.941	.735	.531	.377	.262	.178	.118	.075	.047	.028	.016	.008	.004	.002	.001	.000
	1	.057	.232	.354	.399	.393	.356	.303	.244	.187	.136	.094	.061	.037	.020	.010	.004
	2	.001	.031	.098	.176	.246	.297	.324	.328	.311	.278	.234	.186	.138	.095	.060	.033
	3	.000	.002	.015	.042	.082	.132	.185	.236	.276	.303	.312	.303	.276	.236	.185	.132
	4	.000	.000	.001	.006	.015	.033	.060	.095	.138	.186	.234	.278	.312	.328	.324	.297
	5	.000	.000	.000	.000	.002	.004	.010	.020	.037	.061	.094	.136	.187	.244	.303	.356
	6	.000	.000	.000	.000	.000	.000	.001	.002	.004	.008	.016	.028	.047	.075	.118	.178

The value at the intersection is the probability of obtaining exactly 4 successes. Therefore, the probability that Jessica makes exactly 4 out of 6 free throws is **0.311**. This direct lookup method

works efficiently when the table provides individual probability mass function (PMF) values.

Example 2: Calculating "Less Than" Probabilities ($P(X < r)$)

Question: Jessica makes 60% of her free-throw attempts. If she shoots 6 free throws, what is the probability that she makes **less than 4**?

When asked for a probability range, such as "less than 4," we are interested in all possible outcomes where the number of successes (X) is strictly less than 4. Since the number of trials is 6, the relevant outcomes are $X = 0$, $X = 1$, $X = 2$, and $X = 3$.

To find this total probability, we must sum the individual probabilities for each outcome in the specified range. This is known as calculating the cumulative probability for $P(X \leq 3)$:

$$P(\text{makes less than 4}) = P(X = 0) + P(X = 1) + P(X = 2) + P(X = 3)$$

We look up each of these four individual probabilities ($P(X=r)$) in the binomial distribution table for $n = 6$ and $p = 0.60$, and then perform the necessary addition:

n	r	p															
		.01	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75
2	0	.980	.902	.810	.723	.640	.563	.490	.423	.360	.303	.250	.203	.160	.123	.090	.063
	1	.020	.095	.180	.255	.320	.375	.420	.455	.480	.495	.500	.495	.480	.455	.420	.375
	2	.000	.002	.010	.023	.040	.063	.090	.123	.160	.203	.250	.303	.360	.423	.490	.563
3	0	.970	.857	.729	.614	.512	.422	.343	.275	.216	.166	.125	.091	.064	.043	.027	.016
	1	.029	.135	.243	.325	.384	.422	.441	.444	.432	.408	.375	.334	.288	.239	.189	.141
	2	.000	.007	.027	.057	.096	.141	.189	.239	.288	.334	.375	.408	.432	.444	.441	.422
	3	.000	.000	.001	.003	.008	.016	.027	.043	.064	.091	.125	.166	.216	.275	.343	.422
4	0	.961	.815	.656	.522	.410	.316	.240	.179	.130	.092	.062	.041	.026	.015	.008	.004
	1	.039	.171	.292	.368	.410	.422	.412	.384	.346	.300	.250	.200	.154	.112	.076	.047
	2	.001	.014	.049	.098	.154	.211	.265	.311	.346	.368	.375	.368	.346	.311	.265	.211
	3	.000	.000	.004	.011	.026	.047	.076	.112	.154	.200	.250	.300	.346	.384	.412	.422
	4	.000	.000	.000	.001	.002	.004	.008	.015	.026	.041	.062	.092	.130	.179	.240	.316
5	0	.951	.774	.590	.444	.328	.237	.168	.116	.078	.050	.031	.019	.010	.005	.002	.001
	1	.048	.204	.328	.392	.410	.396	.360	.312	.259	.206	.156	.113	.077	.049	.028	.015
	2	.001	.021	.073	.138	.205	.264	.309	.336	.346	.337	.312	.276	.230	.181	.132	.088
	3	.000	.001	.008	.024	.051	.088	.132	.181	.230	.276	.312	.337	.346	.336	.309	.264
	4	.000	.000	.000	.002	.006	.015	.028	.049	.077	.113	.156	.206	.259	.312	.360	.396
	5	.000	.000	.000	.000	.000	.001	.002	.005	.010	.019	.031	.050	.078	.116	.168	.237
6	0	.941	.735	.531	.377	.262	.178	.118	.075	.047	.028	.016	.008	.004	.002	.001	.000
	1	.057	.232	.354	.399	.393	.356	.303	.244	.187	.136	.094	.061	.037	.020	.010	.004
	2	.001	.031	.098	.176	.246	.297	.324	.328	.311	.278	.234	.186	.138	.095	.060	.033
	3	.000	.002	.015	.042	.082	.132	.185	.236	.276	.303	.312	.303	.276	.236	.185	.132
	4	.000	.000	.001	.006	.015	.033	.060	.095	.138	.186	.234	.278	.311	.328	.324	.297
	5	.000	.000	.000	.000	.002	.004	.010	.020	.037	.061	.094	.136	.187	.244	.303	.356
6	.000	.000	.000	.000	.000	.000	.001	.002	.004	.008	.016	.028	.047	.075	.118	.178	

By extracting the corresponding values from the table (highlighted in the image), we find: $P(X < 4)$

= 0.004 + 0.037 + 0.138 + 0.276. Summing these values yields the final result.

Calculation: $P(\text{makes less than 4}) = 0.004 + 0.037 + 0.138 + 0.276 = \mathbf{0.455}$. Therefore, the probability that Jessica makes less than 4 free throws is **0.455**.

Example 3: Calculating "Greater Than or Equal To" Probabilities ($P(X \geq r)$)

Question: Jessica makes 60% of her free-throw attempts. If she shoots 6 free throws, what is the probability that she makes **4 or more**?

To determine the probability of "4 or more" successes, we must identify all outcomes where the number of successes (X) is greater than or equal to 4. Given $n = 6$, the relevant outcomes are $X = 4$, $X = 5$, and $X = 6$.

We sum the individual probabilities for these events, $P(X \geq 4)$, using the same parameters ($n = 6$, $p = 0.60$):

$$P(\text{makes 4 or more}) = P(X = 4) + P(X = 5) + P(X = 6)$$

We consult the binomial table again, retrieving the probabilities associated with 4, 5, and 6 successes:

n	r	p															
		.01	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75
2	0	.980	.902	.810	.723	.640	.563	.490	.423	.360	.303	.250	.203	.160	.123	.090	.063
	1	.020	.095	.180	.255	.320	.375	.420	.455	.480	.495	.500	.495	.480	.455	.420	.375
	2	.000	.002	.010	.023	.040	.063	.090	.123	.160	.203	.250	.303	.360	.423	.490	.563
3	0	.970	.857	.729	.614	.512	.422	.343	.275	.216	.166	.125	.091	.064	.043	.027	.016
	1	.029	.135	.243	.325	.384	.422	.441	.444	.432	.408	.375	.334	.288	.239	.189	.141
	2	.000	.007	.027	.057	.096	.141	.189	.239	.288	.334	.375	.408	.432	.444	.441	.422
	3	.000	.000	.001	.003	.008	.016	.027	.043	.064	.091	.125	.166	.216	.275	.343	.422
4	0	.961	.815	.656	.522	.410	.316	.240	.179	.130	.092	.062	.041	.026	.015	.008	.004
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	2	.001	.014	.049	.098	.154	.211	.265	.311	.346	.368	.375	.368	.346	.311	.265	.211
	3	.000	.000	.004	.011	.026	.047	.076	.112	.154	.200	.250	.300	.346	.384	.412	.422
	4	.000	.000	.000	.001	.002	.004	.008	.015	.026	.041	.062	.092	.130	.179	.240	.316
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	2	.001	.021	.073	.138	.205	.264	.309	.336	.346	.337	.312	.276	.230	.181	.132	.088
	3	.000	.001	.008	.024	.051	.088	.132	.181	.230	.276	.312	.337	.346	.336	.309	.264
	4	.000	.000	.000	.002	.006	.015	.028	.049	.077	.113	.156	.206	.259	.312	.360	.396
	5	.000	.000	.000	.000	.000	.001	.002	.005	.010	.019	.031	.050	.078	.116	.168	.237
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	5	.000	.000	.000	.000	.002	.004	.010	.020	.037	.061	.094	.136	.187	.244	.303	.356
	6	.000	.000	.000	.000	.000	.000	.001	.002	.004	.008	.016	.028	.047	.075	.118	.178

Using the highlighted values from the table: $P(X \geq 4) = 0.311 + 0.187 + 0.047$.

Calculation: $P(\text{makes 4 or more}) = 0.311 + 0.187 + 0.047 = \mathbf{0.545}$. This demonstrates how to calculate upper-tail probabilities using an individual probability table.

Alternative Method: Using the Complement Rule

For calculating $P(X \geq r)$, particularly when r is small (meaning you have many individual probabilities to sum), using the complement rule often provides a faster and more reliable method. The complement rule states that the probability of an event occurring is 1 minus the probability of the event not occurring.

In Example 3, we wanted $P(X \geq 4)$. The complement of making 4 or more free throws is making 3 or fewer ($P(X \leq 3)$).

Therefore: $\mathbf{P(X \geq 4) = 1 - P(X \leq 3)}$.

We already calculated $P(X \leq 3)$ in Example 2, where we found $P(X < 4) = P(X \leq 3) = 0.455$.

Applying the complement rule: $P(X \geq 4) = 1 - 0.455 = \mathbf{0.545}$.

This result precisely matches the sum calculated in Example 3 ($0.311 + 0.187 + 0.047 = 0.545$). For calculations involving larger ranges, mastering the complement rule is essential for efficient statistical analysis, especially when working with cumulative probability tables.

Limitations and Transition to Modern Computation

While the Binomial Distribution Table remains a cornerstone of introductory statistics education, it possesses inherent limitations. Firstly, these tables can only practically cover small values of **n** (the number of trials) and a limited set of discrete **p** values (e.g., 0.05, 0.10, 0.20, etc.). If an experiment involves $n = 100$ or $p = 0.63$, the exact value cannot be found directly in a standard printed table.

Secondly, the precision is often limited to three or four decimal places. For high-stakes modeling or advanced research, greater accuracy is typically required. Furthermore, the tables become unwieldy and impractical as **n** increases. When **n** is very large and **p** is small, the Poisson distribution can be used as an approximation, and when both **n** is large and **p** is close to 0.5, the normal distribution provides an excellent approximation, transitioning the problem away from the rigid structure of the binomial table.

In professional and academic settings today, software packages like R, Python (with libraries like SciPy), and dedicated statistical calculators are preferred. These tools allow instant calculation of both PMF and CDF for any combination of **n**, **r**, and **p**, regardless of the magnitude, offering far greater flexibility and precision than manual table lookups. However, understanding the table's structure is key to interpreting the output of these modern computational methods.