

How to Calculate Probabilities with the Binomial Distribution in Excel

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The **binomial distribution** is a fundamental concept in **statistics**, allowing us to model the number of successes in a fixed number of independent trials. In Excel, this powerful tool enables the calculation of the **probability** of achieving a specified number of successes within a fixed series of attempts, provided the probability of success for a single trial remains constant.

The core function for these calculations is **BINOM.DIST**. To utilize this function effectively, four critical inputs are required: the total number of trials, the specific number of desired successes, the fixed probability of success on any single trial, and a logical indicator determining whether to calculate the exact probability of that count or the **cumulative probability** (the probability of that number of successes or fewer).

Understanding the Binomial Distribution Family in Excel

The binomial model is central to analytical decision-making and forecasting. This distribution is indispensable whenever we deal with phenomena that have only two possible outcomes--success or failure--over a series of independent trials. It forms the backbone of various statistical tests and predictive modeling in numerous fields, from finance to quality control.

Excel provides a suite of powerful functions specifically designed to manage binomial probability calculations efficiently and accurately. These functions allow users to move beyond simple point probabilities and analyze complex ranges and inverse cumulative distribution questions. This guide focuses on the practical application of the three primary functions used for solving complex binomial problems:

BINOM.DIST: Calculates the exact or cumulative probability of a specific number of successes.

BINOM.DIST.RANGE: Calculates the probability of successes falling within a defined range.

BINOM.INV: Calculates the smallest number of successes required to meet a specified cumulative probability threshold (the inverse calculation).

Using BINOM.DIST for Exact and Cumulative Probabilities

The **BINOM.DIST** function is the cornerstone of binomial analysis in Excel. It is specifically designed to calculate the likelihood of observing a precise number of favorable outcomes (successes) across a predefined set of independent trials, assuming the underlying probability of success remains constant throughout the process. This function is essential for both precise point estimates and broader cumulative assessments.

Understanding the required arguments is crucial for correct implementation. The formal syntax structure for the **BINOM.DIST** formula is detailed below, followed by a breakdown of each component:

BINOM.DIST(number_s, trials, probability_s, cumulative)

number_s: Specifies the specific count of successes for which you are calculating the probability.

trials: Represents the total count of independent trials or observations in the experiment (n).

probability_s: Defines the constant probability of success associated with each individual trial (p).

cumulative: This is a logical value (TRUE or FALSE). Setting it to **TRUE** calculates the **cumulative probability** ($P(X \leq \text{number_s})$). Setting it to **FALSE** calculates the exact probability mass function ($P(X = \text{number_s})$).

To solidify the application of this function, the following scenarios demonstrate how to use **BINOM.DIST** to solve practical problems involving both exact and cumulative binomial probabilities.

Calculating Exact Probability ($P(X=k)$)

Consider a scenario where **Nathan** has a consistent free-throw success rate of 60% (0.6). If he attempts 12 free throws in a game, we want to determine the precise probability that he makes **exactly 10** shots. This scenario requires a specific point calculation, excluding the probabilities of making 9 or fewer, or 11 or 12 shots.

Since we are looking for an exact count, the `cumulative` argument must be set to **FALSE**. The parameters are: successes=10, trials=12, probability_s=0.6, cumulative=FALSE. The corresponding Excel formula is: **BINOM.DIST(10, 12, 0.6, FALSE)**

	A	B	C	D
1	Formula			
2	=BINOM.DIST(10, 12, 0.6, FALSE)			
3	Answer			
4	0.063852			
5				

The calculated result shows that the chance of Nathan making precisely 10 out of 12 free throws is approximately **0.063852**.

Calculating Cumulative Probability ($P(X \leq k)$)

In this example, **Marty** flips a fair coin 5 times. Since the coin is fair, the probability of landing heads (success) on any flip is 0.5. We aim to find the likelihood that the coin lands on heads **2 times or fewer** ($P(X \leq 2)$). This includes the outcomes of 0, 1, or 2 heads.

To calculate this range, we must use the **cumulative probability** feature by setting the final argument to **TRUE**. The parameters are: successes=2, trials=5, probability_s=0.5, cumulative=TRUE. The correct formula implementation is: **BINOM.DIST(2, 5, 0.5, TRUE)**

	A	B	C	D
1	Formula			
2	=BINOM.DIST(2, 5, 0.5, TRUE)			
3	Answer			
4	0.5			
5				

The calculation yields the total probability for 0, 1, or 2 successes.

Calculating Inverse Cumulative Probability ($P(X > k)$)

When determining the probability of outcomes **greater than** a certain number ($P(X > k)$), we must employ the concept of complementary probability. If **Mike** flips a fair coin 5 times and we want the probability of getting **more than 3 heads** (i.e., 4 or 5 heads), we cannot calculate this directly using the standard cumulative function, as **BINOM.DIST** only calculates $P(X \leq k)$.

We must first calculate the **cumulative probability** of getting 3 or fewer heads ($P(X \leq 3)$) and subtract this result from 1. This uses the logic: $P(X > 3) = 1 - P(X \leq 3)$. The required formula in Excel is: **1 - BINOM.DIST(3, 5, 0.5, TRUE)**

	A	B	C	D
1	Formula			
2	=1 - BINOM.DIST(3, 5, 0.5, TRUE)			
3	Answer			
4	0.1875			
5				

Executing this formula yields the probability of **0.1875**, representing the chance of Mike getting 4 or 5 heads.

Important Note: The **BINOM.DIST** function, when set to **TRUE**, always calculates the probability of less than or equal to the specified number of successes. Therefore, to calculate $P(X > k)$, always subtract $P(X \leq k)$ from 1.

Analyzing Probability Ranges with BINOM.DIST.RANGE

While **BINOM.DIST** calculates single points or cumulative values from zero, the **BINOM.DIST.RANGE** function provides a streamlined method for calculating the probability that the number of successes falls within a specific, closed interval. This function is particularly useful when analyzing outcomes that must meet both minimum and maximum criteria without performing manual subtractions of cumulative distributions.

The function assumes the same underlying conditions as the standard **binomial distribution** calculation: fixed trials and a constant probability of success. The syntax requires four arguments to define the scope of the calculation:

BINOM.DIST.RANGE(trials, probability_s, number_s, number_s2)

trials: The total count of repetitions in the binomial experiment.

probability_s: The fixed probability of success (p) on each trial.

number_s: Defines the minimum number of successes required (k1). This value is inclusive.

number_s2: Defines the maximum number of successes allowed (k2). This value is inclusive. If omitted, the function calculates the exact probability of **number_s** successes ($P(X = k1)$).

The following examples demonstrate how **BINOM.DIST.RANGE** simplifies finding probabilities across a bounded range of outcomes.

Calculating Probability Between Two Points

If **Debra** flips a fair coin 5 times (where $p=0.5$), we are interested in the probability of observing the number of heads (successes) falling inclusively between 2 and 4 (i.e., 2, 3, or 4 heads).

This calculation is directly mapped to the **BINOM.DIST.RANGE** function by setting the minimum successes to 2 and the maximum successes to 4. The formula used is: **BINOM.DIST.RANGE(5, 0.5, 2, 4)**

	A	B	C	D
1	Formula			
2	=BINOM.DIST.RANGE(5, 0.5, 2, 4)			
3	Answer			
4	0.78125			
5				

The resulting probability for achieving between 2 and 4 heads is **0.78125**.

Analyzing Population Samples

Assume a population parameter where 70% (0.7) of men endorse a specific law. If a sample of 10 men is randomly chosen, we want to calculate the likelihood that the number of supporters falls within the range of 4 to 6 (inclusive). This scenario perfectly fits the binomial distribution model.

We define 10 trials, a success probability of 0.7, a minimum of 4 successes, and a maximum of 6 successes. The Excel calculation is: **BINOM.DIST.RANGE(10, 0.7, 4, 6)**

	A	B	C	D
1	Formula			
2	=BINOM.DIST.RANGE(10, 0.7, 4, 6)			
3	Answer			
4	0.339797			
5				

The computed probability that between 4 and 6 men in the sample support the law is **0.339797**.

Working with Large Trials and High Probabilities

For situations involving a large number of trials ($n=30$) and a high success probability ($p=0.9$), like **Teri's** free throws, **BINOM.DIST.RANGE** remains highly effective. We want to find the probability of her success rate falling inclusively between 15 and 25 made shots.

The formula inputs are: 30 trials, 0.9 probability of success, a minimum of 15 successes, and a maximum of 25 successes. The resulting Excel function call is: **BINOM.DIST.RANGE(30, .9, 15, 25)**

	A	B	C	D
1	Formula			
2	=BINOM.DIST.RANGE(30, .9, 15, 25)			
3	Answer			
4	0.175495			
5				

The likelihood of Teri successfully making between 15 and 25 free throws is calculated as **0.175495**.

Using BINOM.INV for Inverse Cumulative Calculations

The **BINOM.INV** function performs the inverse of the cumulative binomial calculation. Instead of providing the number of successes (k) and calculating the cumulative probability $P(X \leq k)$, we provide a probability threshold (alpha) and Excel determines the smallest integer value of k such that the **cumulative probability** of achieving k successes or fewer is greater than or equal to that threshold.

This function is crucial in fields like quality control and hypothesis testing where minimum performance metrics must be established based on specific confidence levels. It helps answer questions like, "How many successes do I need to be 90% certain of achieving at least that result?" The syntax is straightforward, requiring only three arguments:

BINOM.INV(trials, probability_s, alpha)

trials: The total number of fixed observations (n).

probability_s: The probability of success (p) on each individual trial.

alpha: The critical threshold value (or significance level) between 0 and 1. **BINOM.INV** returns the smallest number of successes (k) where $P(X \leq k) \geq \alpha$.

The following examples showcase how to utilize **BINOM.INV** to find the minimum number of successes required to meet a specific cumulative confidence level.

Finding the Success Threshold (n=10)

Suppose **Duane** flips a fair coin 10 times ($p=0.5$). We are asked to find the minimum number of heads (k) required such that the **cumulative probability** of getting k or fewer heads is at least 0.4.

We input the total trials (10), the probability of success (0.5), and the alpha threshold (0.4). The resulting formula is: **BINOM.INV(10, 0.5, 0.4)**

	A	B	C	D
1	Formula			
2	=BINOM.INV(10, 0.5, 0.4)			
3	Answer			
4	5			

The function returns **5**, meaning that the cumulative probability of getting 5 or fewer heads is the first value in the distribution that meets or exceeds the 0.4 criterion.

Finding the Success Threshold (n=20)

If we increase the number of trials to 20, keeping the success probability at 0.5, we recalculate the threshold for the 0.4 alpha level. As the number of trials (n) increases, the **binomial distribution** becomes more symmetrical around the expected value ($n \cdot p$).

The Excel formula is adjusted for the new trial count: **BINOM.INV(20, 0.5, 0.4)**

	A	B	C	D
1	Formula			
2	=BINOM.INV(20, 0.5, 0.4)			
3	Answer			
4	9			
5				

For 20 trials, the smallest number of successes needed to reach or surpass a cumulative probability of 0.4 is **9**.

Applying Thresholds to Alternative Outcomes (Tails)

In this final example, Duane increases the trials to 30. We are now defining "success" as the coin landing on **tails**, maintaining a success probability of 0.5. We seek the smallest number of tails (k) such that the cumulative probability $P(X \leq k)$ meets or exceeds the 0.7 threshold.

Using the correct parameters (30 trials, 0.5 probability, 0.7 alpha), the formula should be: **BINOM.INV(30, 0.5, 0.7)**

	A	B	C	D
1	Formula			
2	=BINOM.INV(30, 0.5, 0.7)			
3	Answer			
4	16			
5				

The calculation confirms that the smallest number of tails required to reach a **cumulative probability** of 0.7 or higher is **16**.