

Binomial Test in Excel: A Comprehensive Guide with Examples

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Understanding the Binomial Test

The [binomial test](#) stands as a cornerstone in statistical analysis, specifically designed for situations involving discrete, dichotomous outcomes--events that can only result in one of two possibilities, traditionally labeled "success" or "failure." This powerful non-parametric test allows researchers to rigorously compare an observed [sample proportion](#) against a known or assumed population rate, often referred to as the [hypothesized proportion](#) (π or p ?). By conducting this comparison, we can determine whether any deviation observed in our sample is statistically meaningful, suggesting a genuine difference in the population, or if it is merely the product of random sampling variation.

To grasp the practical application of this test, consider a universally understood scenario involving probability: rolling a standard, six-sided die. Assuming the die is perfectly fair, the theoretical probability of rolling any specific outcome, such as the number "3," is fixed at $1/6$. If we were to conduct 24 independent rolls (trials), the mathematical expectation dictates that the number "3" should appear exactly four times (24 multiplied by $1/6$). This expected frequency establishes the necessary baseline against which any real-world observations must be judged.

Now, suppose we perform the 24 rolls and observe the number "3" appearing six times. While this result (6) is numerically greater than the expected frequency (4), the fundamental statistical challenge remains: Is this increase sufficiently significant to furnish compelling [evidence](#) that the die is inherently biased toward rolling a "3," or does this outcome still fall within the normal, expected bounds of random fluctuation? The binomial test provides the structured framework and the precise mathematical tools needed to quantify this likelihood, enabling us to make an informed, data-driven decision regarding the fairness of the die.

The Core Excel Function: BINOM.DIST

Microsoft Excel simplifies the complex calculations required for the binomial test through its robust statistical function, [BINOM.DIST](#). This function is instrumental because it calculates the probabilities associated with a binomial distribution, allowing us to accurately determine the likelihood of observing a specified number of successes given a fixed number of trials and a constant probability of success for each trial. Understanding the parameters of this function is essential for its correct application in hypothesis testing.

The functional structure used within Excel is defined precisely by the following arguments:

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

Each argument plays a unique and critical role in modeling the specific binomial distribution under examination:

number_s: Represents the specific count of "successes" that have either been observed in the sample or are being evaluated as part of the statistical test.

trials: Defines the total number of independent observations or trials conducted, such as the total count of coin flips, production units tested, or die rolls.

probability_s: This is the theoretical or hypothesized probability of success for any single trial, typically derived from the assumptions of the [null hypothesis](#).

cumulative: This is a logical value (either **TRUE** or **FALSE**) that dictates the specific type of probability calculation returned by the function.

If set to **FALSE**, [BINOM.DIST](#) returns the [Probability Mass Function](#) (PMF)--the exact probability of achieving precisely **number_s** successes.

If set to **TRUE**, it returns the [cumulative distribution function](#) (CDF)--the probability of achieving at most **number_s** successes ($P(X \leq \text{number_s})$). For the majority of standard hypothesis tests, we use **TRUE** because we are generally interested in the probability of obtaining results as extreme as, or more extreme than, our observation.

The subsequent examples will clearly illustrate the practical methods for integrating this function into an Excel worksheet, detailing how to correctly configure the formula to calculate the necessary p-values essential for statistical decision-making.

Applying the Binomial Test: One-Tailed Example (Die Bias)

We return to our initial die rolling scenario to execute the complete binomial test procedure. This specific setup constitutes a one-tailed test because our concern is directional--we are only interested in establishing whether the die exhibits a bias toward the number "3," not merely that it is different from the expected rate.

Example 1: We roll a fair 6-sided die 24 times and observe that it lands on the number "3" exactly 6 times. We must perform a binomial test to formally determine if the die is statistically biased towards the number "3."

The critical first step is the formal statement of the null and alternative hypotheses, where π represents the true population proportion (the true probability of rolling a "3"):

$H_0: \pi \leq 1/6$ (The die is fair or potentially biased against the number "3"--there is no positive bias.)

$H_A: \pi > 1/6$ (The die is biased towards the number "3"--a statistically significant positive bias exists.)

Since our alternative hypothesis (H_A) is directional, we are testing whether the outcome of 6 successes or more is unusual. We need to calculate the probability $P(x \geq 6)$. Critically, because the [BINOM.DIST](#) function set to **TRUE** only calculates the cumulative probability $P(x \leq \text{number_s})$, we

must employ the statistical rule of complements: $P(x \geq 6) = 1 - P(x \leq 5)$. We use 5 as the upper limit because we must exclude the probability of the observed outcome (6) and all outcomes greater than it.

The formula entered into Excel for this calculation is:

$$P(x \geq 6) = 1 - \text{BINOM.DIST}(5, 24, 1/6, \text{TRUE}) = 1 - 0.80047 = \mathbf{0.19953}.$$

This result, 0.19953, is our calculated [p-value](#). To reach a conclusion, this value is compared against our predetermined [significance level](#) (alpha, typically 0.05). Since 0.19953 is substantially larger than 0.05, we conclude that the probability of observing 6 or more successes purely by chance is relatively high (nearly 20%). Therefore, we **fail to reject the null hypothesis**. We do not possess sufficient statistical evidence to definitively conclude that the die is biased towards the number "3."

Analyzing Coin Bias: A Second Practical Application

The binomial test is an ideal methodology for analyzing random, Bernoulli-like processes such as coin flips, where the expected probability of success is unequivocally defined ($p = 0.5$). This second example demonstrates the procedure with an increased number of trials, again testing for a specific directional bias (one-tailed test).

Example 2: We flip a standard coin 30 times and it lands on heads exactly 19 times. Perform a binomial test to determine if the coin is statistically biased towards heads.

Assuming the coin is fundamentally fair, the hypothesized probability of heads (π) is 0.5. Our hypothesis test is structured as follows:

$H_0: \pi \leq 0.5$ (The coin is fair or potentially biased against heads.)

$H_A: \pi > 0.5$ (The coin is biased towards heads.)

We observed 19 heads in 30 trials, and we are concerned with the likelihood of achieving 19 or more heads, denoted $P(x \geq 19)$. As before, we must calculate the complement of the cumulative probability up to 18 successes, using the maximum count we are willing to accept under the null hypothesis assumption:

The formula we input into Excel is:

$$P(x \geq 19) = 1 - \text{BINOM.DIST}(18, 30, 1/2, \text{TRUE}) = 1 - 0.89976 = \mathbf{0.10024}.$$

With the resulting [p-value](#) of 0.10024, we compare it against the conventional [alpha level](#) of 0.05. Since 0.10024 remains greater than 0.05, the observed data does not provide adequate statistical

evidence to reject the [null hypothesis](#). Although 19 heads is numerically higher than the expected 15, this specific deviation is still statistically plausible under the assumption that the coin is fair. Consequently, we cannot conclude that the coin is biased towards heads based on the results of this sample.

Testing Production Improvements: Rejecting the Null Hypothesis

It is important to understand that the goal of hypothesis testing is not always to fail to reject the null hypothesis. The binomial test is most valuable when it successfully identifies a true, statistically significant change in the underlying population proportion. This following industrial example illustrates a scenario where the evidence is sufficiently strong to confirm a purported improvement.

Example 3: A manufacturing shop historically produces widgets with an 80% effectiveness rate ($\pi = 0.80$). They implement a costly new production system designed specifically to enhance this reliability. A random sample of 50 widgets from the new production run reveals that 46 of them are effective. We perform a binomial test to determine if the new system leads to a statistically significant higher rate of effectiveness.

The hypotheses are formulated to test the observed success rate ($46/50 = 92\%$) against the historical baseline of 80%:

$H_0: \pi \leq 0.80$ (The new system does not result in an increase in effectiveness.)

$H_A: \pi > 0.80$ (The new system successfully increased the effectiveness rate.)

We must calculate the probability of observing 46 or more effective widgets out of 50 trials, assuming the baseline probability remains 0.80. Utilizing the complement rule, we calculate 1 minus the [cumulative distribution function](#) for 45 or fewer successes:

The required formula for Excel entry is:

$$P(x \geq 46) = 1 - \text{BINOM.DIST}(45, 50, 0.8, \text{TRUE}) = 1 - 0.9815 = \mathbf{0.0185}.$$

The resulting [p-value](#) is 0.0185. Crucially, this value is **less than the significance level of 0.05**. This exceptionally low probability suggests that observing 46 effective widgets would be highly improbable if the true effectiveness rate were still only 80%. Because the evidence strongly contradicts the null hypothesis, we confidently **reject the null hypothesis**. We therefore conclude that there is sufficient statistical evidence to confirm that the new system implemented by the shop has successfully led to a statistically significant increase in widget effectiveness.

Determining Critical Successes Using BINOM.INV (The Inverse Approach)

While the [BINOM.DIST](#) function calculates the probability of a given outcome, statisticians often require an inverse calculation: determining the critical threshold, or the minimum number of successes required in a sample to achieve a predefined level of statistical significance. For this specific purpose, Excel provides the specialized inverse binomial function.

Example 4: A shop produces gadgets with a known reliability rate of 60% ($\pi = 0.60$). They introduce a new manufacturing process aimed at improving this reliability. If they randomly sample 40 gadgets, what is the minimum number of reliable gadgets they must observe to claim, with 95% confidence ($\alpha = 0.05$), that the new process improved reliability?

To solve this, we must utilize the [BINOM.INV](#) function. This function is designed to find the smallest integer value 'x' for which the [cumulative distribution function](#) is greater than or equal to a specified probability criterion.

The structure of the inverse function is straightforward:

BINOM.INV(trials, probability_s, alpha)

The arguments are defined as follows in the context of our example:

trials: The total sample size, which is 40 observations.

probability_s: The [hypothesized proportion](#) of "success" under the assumption of the null hypothesis (0.60).

alpha: The desired probability threshold. Because [BINOM.INV](#) calculates $P(X \leq x) \geq \alpha$, and we are performing a right-tailed test (testing for improvement, or $X > x$), we must set alpha to 1 minus our desired [significance level](#). For 95% confidence ($\alpha=0.05$), we set the argument to 0.95. This finds the value 'x' where the probability of being greater than 'x' is less than 0.05.

We enter the following formula into Excel:

`BINOM.INV(40, 0.60, 0.95) = 29.`

The resulting output of 29 establishes the critical value for this test. Therefore, in order to achieve a statistically significant result at the 0.05 significance level and successfully reject the [null hypothesis](#), the shop would need to observe at least **29** of the 40 gadgets functioning reliably. If the observed number of reliable gadgets is 28 or fewer, the shop would lack sufficient evidence to confidently state that the new process led to a statistical improvement in reliability.