

# Bayesian Diagnostic Insights

A Software Tool for Parametric Bayesian Probabilistic Methods in Medical Diagnostics

Interface Documentation

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## 1. Introduction

The *Bayesian Diagnostic Insights* software program is a specialized computational tool developed to assist medical professionals and researchers in the field of diagnostics. The program allows for the calculation, and plotting of four Bayesian diagnostic measures: positive predictive value [ $P(D|T > t)$ ], negative predictive value [ $P(\bar{D}|T < t)$ ], posterior probability for disease [ $P(D|T = t)$ ], and posterior probability for the absence of disease [ $P(\bar{D}|T = t)$ ]. Utilizing the principles of uncertainty propagation, the program allows for the calculation, and plotting of the sampling, measurement, and combined uncertainty of these measures and of the associated confidence intervals.

## 2. System Requirements

### 2.1. Processor

Intel Core i9® or equivalent CPU

### 2.2. System Memory (RAM)

32 GB+ recommended

### 2.3. Operating Systems

Microsoft Windows, Linux, Apple iOS

### 2.4. Software Requirements

Wolfram Player®, freely available at [Wolfram Player](https://www.wolfram.com/player/) or Wolfram Mathematica®.

## 3. Interface Overview

### 3.1. Tabbed Navigation

The program features an intuitive tabbed user interface, designed to streamline user interaction and facilitate effortless navigation across its multiple modules and sub-modules. Each tab is clearly labeled to correspond with its respective module, allowing for quick access to various functionalities.

### 3.2. Numerical Settings: Sliders

The program offers controls for numerical settings, which can be adjusted through sliders.

#### Fine Manipulation

For more precise control, hold down the '*alt*' or '*opt*' key while dragging the mouse. For even finer adjustments, also hold the '*shift*' and/or '*ctrl*' keys.

### 3.3. Non-Numerical Settings

These settings are controlled using buttons. Each button is labeled clearly to indicate its function.

## 4. Input Parameters

The program allows users to input a variety of parameters, each with a specific range:

$$t: \text{maximum}(0, \text{minimum}(\mu_{\bar{D}} - 6\sigma_{\bar{D}}, \mu_D - 6\sigma_D)) - \text{maximum}(\mu_{\bar{D}} + 6\sigma_{\bar{D}}, \mu_D + 6\sigma_D)$$

$$n_D: 2 - 10,000$$

$$\mu_D: 0.1 - 10,000$$

$$\sigma_D: 0.01 - 1,000$$

$$n_{\bar{D}}: 2 - 10,000$$

$$\mu_{\bar{D}}: 0.1 - 10,000$$

$$\sigma_{\bar{D}}: 0.01 - 1,000$$

$$v: 0.001 - 0.999$$

$$n_U: 20 - 10,000$$

$$b_0: 0 - \sigma_{\bar{D}}$$

$$b_1: 0 - 0.1000$$

$$p: 0.900 - 0.999$$

$t, \mu_D, \sigma_D, \mu_{\bar{D}}$ , and  $\sigma_{\bar{D}}$  are defined in arbitrary units.

## 5. Modules and Submodules

The program is organized into four primary modules, each with multiple submodules:

### 5.1. Diagnostic Measures Plots:

Plots:

- a)  $P(D|T \geq t)$  and  $P(D|T = t)$
- b)  $P(\bar{D}|T < t)$  and  $P(\bar{D}|T = t)$
- c)  $P(D|T \geq t) / P(D|T = t)$
- d)  $P(\bar{D}|T < t) / P(\bar{D}|T = t)$ ,

versus:

- a) The measurement value  $t$
- b) The prevalence or prior probability for disease  $v$

### 5.2. Diagnostic Measures Tables:

For a measurement value  $t$ , the following measures are tabulated:

- a)  $P(D|T \geq t)$ ,

- b)  $P(D|T = t)$
- c)  $P(\bar{D}|T < t)$
- d)  $P(\bar{D}|T = t)$
- e)  $P(D|T \geq t) / P(D|T = t)$
- f)  $P(\bar{D}|T < t) / P(\bar{D}|T = t)$

The above modules allow the user to define:

- a) The prevalence or prior probability for disease  $v$ .
- b) The mean and standard deviation of a diseased and a nondiseased population.
- c) The univariate distribution of each population (normal, lognormal, gamma).
- d) The measurement value  $t$ .

### 5.3. Standard Uncertainty Plots:

Plots:

- a) The standard sampling, measurement, and combined uncertainty
- b) The relative standard sampling, measurement, and combined uncertainty
- c) The associated confidence intervals

of:

- a)  $P(D|T \geq t)$  and  $P(D|T = t)$
- b)  $P(\bar{D}|T < t)$  and  $P(\bar{D}|T = t)$

versus:

- a) The measurement value  $t$
- b) The constant contribution  $b_0$  to measurement uncertainty
- c) The measurement uncertainty proportionality constant  $b_1$
- d) The total size of the population sample  $n$
- e) The prior probability for disease  $v$

### 5.4. Standard Uncertainty Tables:

The program tabulates the standard sampling, measurement, and combined uncertainty and relative uncertainty and the associated confidence intervals of:

- a)  $P(D|T > t)$ ,
- b)  $P(D|T = t)$
- c)  $P(\bar{D}|T < t)$
- d)  $P(\bar{D}|T = t)$

for a user defined value of the measurand  $t$  and all the possible combinations of the distributions.

Each of the above modules allows the user to define:

- a) The size, mean, and standard deviation of a sample from each of a diseased and nondiseased populations.
- b) The univariate distribution of each population (normal, lognormal, gamma).

A linear [ $u_m(x) \cong b_0 + b_1 t$ ] or nonlinear [ $u_m(x) = \sqrt{b_0^2 + b_1^2 t^2}$ ] equation of the measurement uncertainty versus the measurement value  $t$ , and the number of the quality control measurements used to derive it.

- c) The measurement value  $t$ .
- d) The confidence level  $p$  of confidence intervals.

## 6. Source Code

### 6.1. Programming language

Wolfram Language

### 6.2. Software source code file format

Wolfram Notebook

### 6.3. Availability

The updated source code is available at: <https://www.hcsl.com/Tools/BayesianDiagnosticInsights/BayesianDiagnosticInsights.nb>

### 6.4. License

The *Bayesian Diagnostic Insights* program is licensed under the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

## 7. Notation and Abbreviations

### 7.1. Parameters

$n_D$  : size of diseased population

$\mu_D$ : mean of diseased population

$\sigma_D$ : standard deviation of diseased population

$n_{\bar{D}}$ : size of nondiseased population

$\mu_{\bar{D}}$  : mean of nondiseased population

$\sigma_{\bar{D}}$  : standard deviation of nondiseased population

$v$  : prevalence or prior probability for disease

$n_U$  : number of quality control measurements

$b_0$  : constant contribution to measurement uncertainty

$b_1$ : measurement uncertainty proportionality constant

$p$  : confidence level

### 7.2. Bayesian Diagnostic Measures

$P(D|T \geq t)$ : positive predictive value

$P(\bar{D}|T < t)$ : negative predictive value

$P(D|T = t)$ : posterior probability for disease

$P(\bar{D}|T = t)$ : posterior probability for the absence of disease

## 8. Conclusion

The *Bayesian Diagnostic Insights* program offers a robust and user-friendly interface for medical professionals and researchers to estimate the uncertainty in Bayesian diagnosis. Its modular design and comprehensive output options make it a valuable tool in the field of medical statistics and diagnostics.

## 9. Permanent Citation:

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