Linear Quadratic, Y is Percent Surviving

The objective of this case study is to investigate how cell survival changes as radiation dose increases and to quantify that response using nonlinear curve fitting in **Isalos Analytics Platform**. In this case study, the **Linear Quadratic, Y is Percent Surviving model** is used to estimate the linear and quadratic components of radiation-induced cell killing using a standard linear-quadratic survival framework.

The dataset used in this case study is a published clonogenic survival dataset describing the survival of **A549** cells after irradiation, published by *Buch et al. In Radiation Oncology (2012)*. It contains radiation dose values and the corresponding percent surviving measurements. In this model, the **independent variable** (X) is the radiation dose in Gy, and the **dependent variable** (Y) is the percent surviving.

The Linear Quadratic, Y is Percent Surviving model describes a decreasing nonlinear relationship in which percent survival declines as radiation dose increases. The equation used in this analysis is:

$$\boldsymbol{Y = 100 \times e^{-(AX+BX^2)}}$$

which is the percent-scaled form of the standard linear-quadratic survival model. In this model, $\boldsymbol{A}$ represents the linear component of radiation-induced cell killing, and $\boldsymbol{B}$ represents the quadratic component.

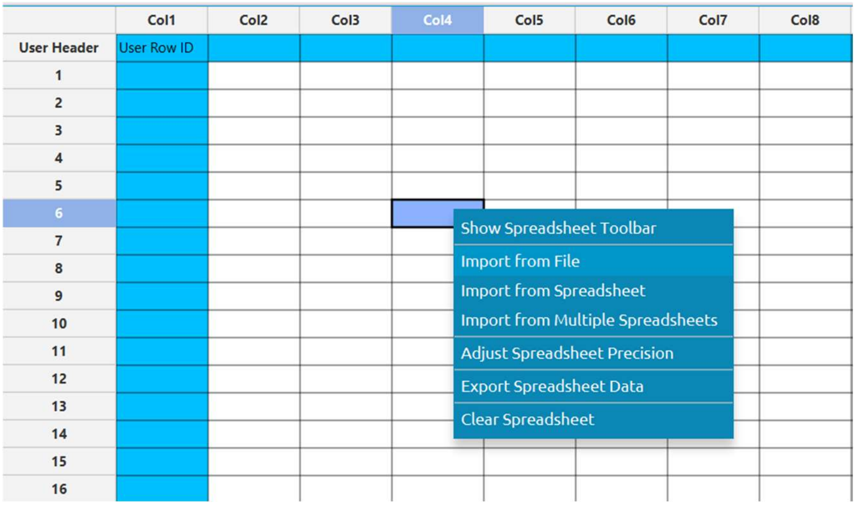
The purpose of this analysis is to determine whether the observed data are consistent with a standard linear-quadratic survival response and to convert the measured survival values into biologically meaningful quantitative outputs. The main results obtained from the fit are $\boldsymbol{A}$ and $\boldsymbol{B}$, where $\boldsymbol{A}$ reflects the contribution of the linear component of cell killing and $\boldsymbol{B}$ reflects the contribution of the quadratic component across the dose range. These results are useful because they allow direct comparison between cell lines, treatments, irradiation conditions, or radiosensitizing interventions, supporting interpretation of radiosensitivity and dose-response behavior.

Isalos version used: 2.0.2

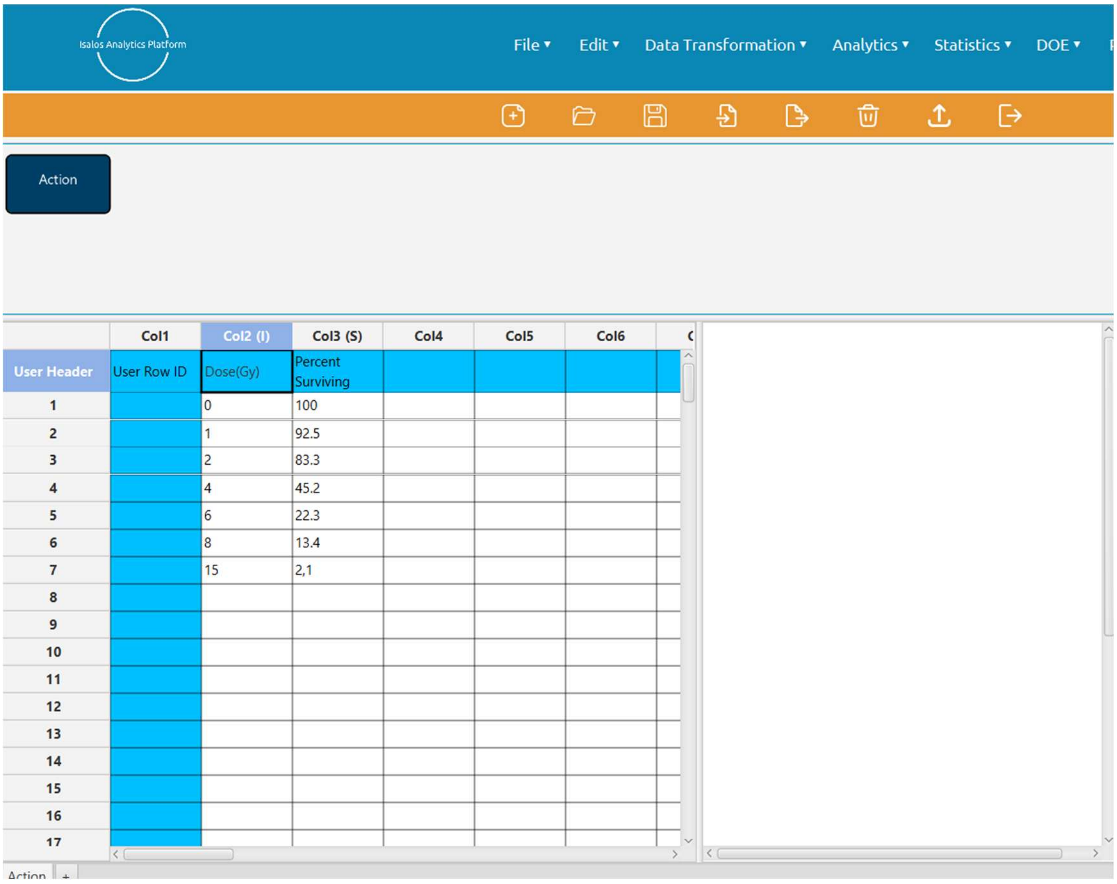
Scientific Article: https://link.springer.com/article/10.1186/1748-717X-7-1

Step 1: Import data from file

Right click on the input spreadsheet (left) and choose the option "**Import from File**". Then navigate through your files to load the one with a XY dataset in which each row corresponds to one radiation dose value and one measured surviving fraction value.

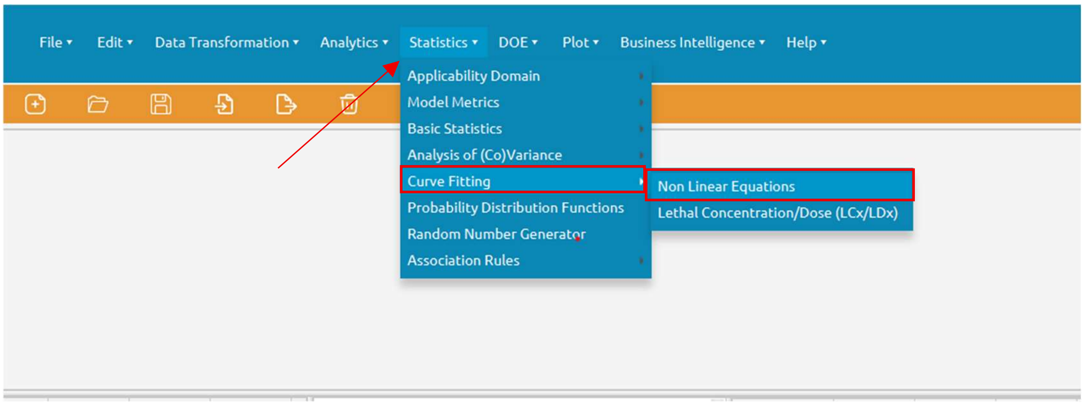


The data will appear on the left spreadsheet.

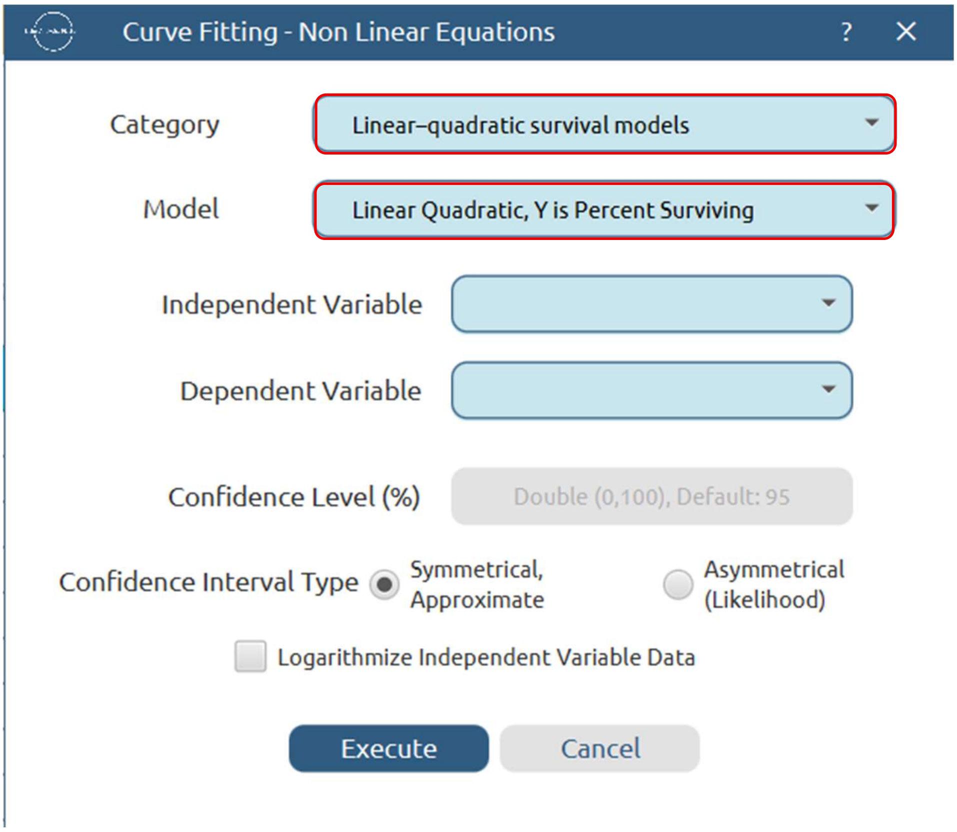


Step 2: Select the Statistic Analysis Model

From the toolbar, click on the **Statistics** drop down list, and then choose the desired model and Equation category navigating through _*Statistics > Curve Fitting > Non Linear Equations.*_

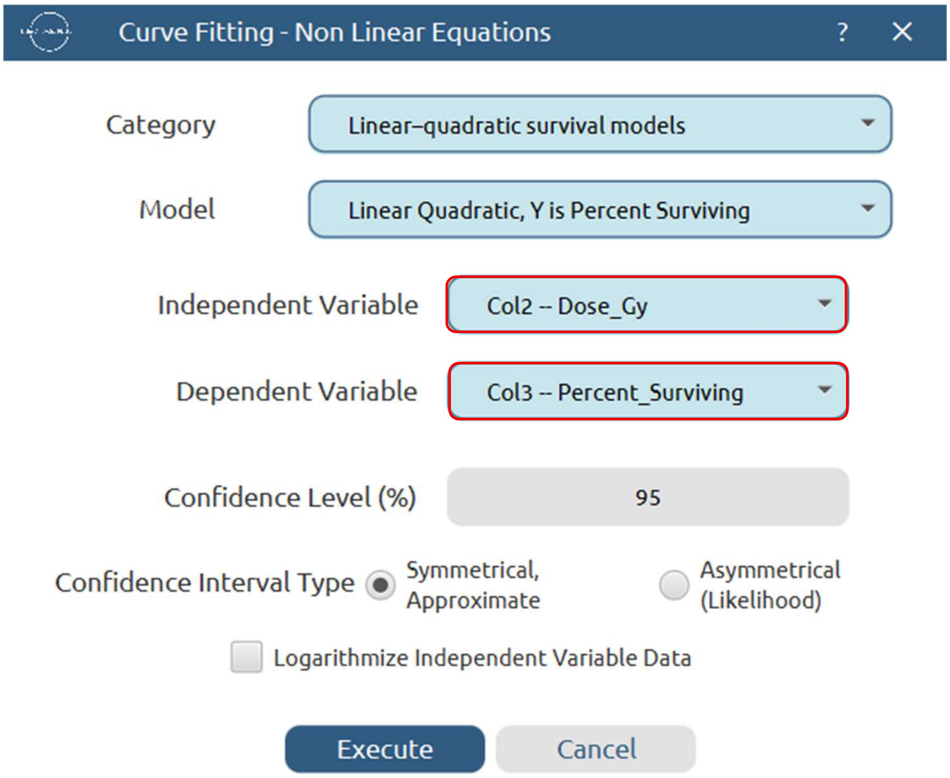


In the category list, select **Linear Quadratic Survival Models** and then choose the **Linear Quadratic, Y is Percent Surviving** model on the model menu.



Step 3: Configure Variables and Confidence Intervals

Set "**Dose_Gy**" as the independent variable X and "**Percent_Surviving**" as the dependent variable Y, using the dataset provided for this case study. Set the confidence level to **95%** and choose **Symmetrical Approximate** as the confidence interval type.

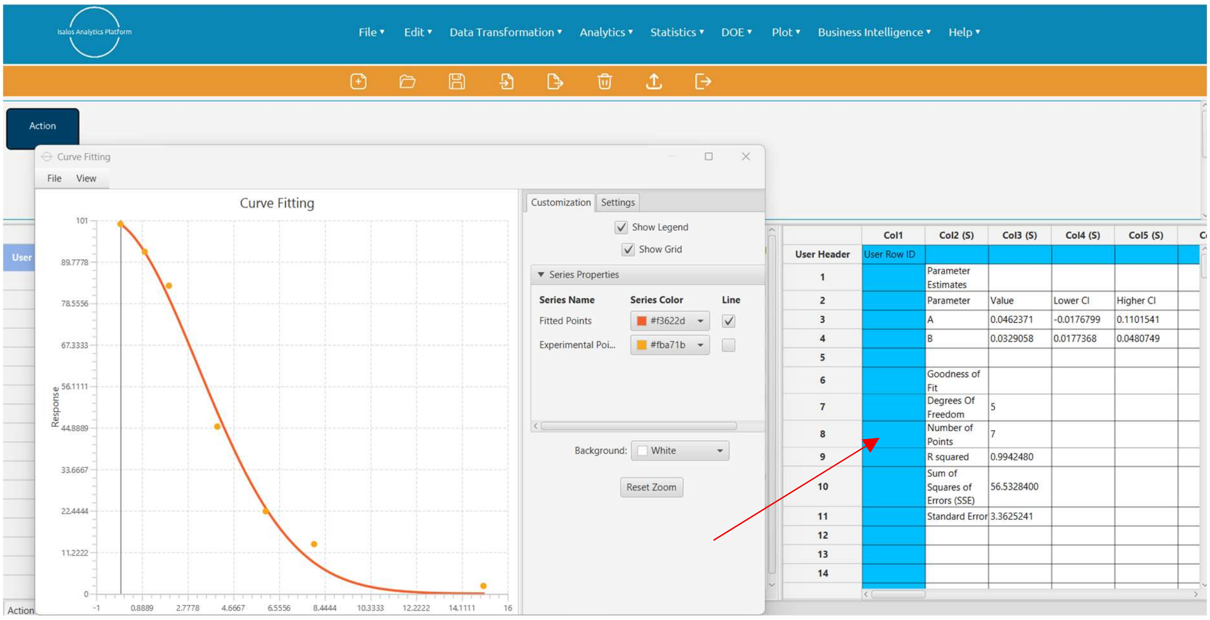


Step 4: Analyzing the Output and Fitted Curves

Once the analysis is completed, Isalos presents the fitted survival curve together with the experimental data points, allowing direct visual assessment of how well the model captures the observed radiation survival pattern.

The results page presents the estimated model parameters with their confidence limits, together with goodness-of-fit statistics and the corresponding fitted plot. In the **Linear Quadratic, Y is Percent Surviving** model, the main fitted parameters are $\boldsymbol{A}$ and $\boldsymbol{B}$, and the graphical output displays a decreasing survival curve in which the percent surviving declines as radiation dose increases.

The **Goodness of Fit** section of the table summarizes key fitting statistics such as **the number of data points used**, **degrees of freedom**, **residual sum of squares**, and the **standard error of the regression**. These outputs should be interpreted together with the fitted plot in order to evaluate how well the model describes the data and how reliable the estimated parameters are.



The fitted results suggest that the survival response of the **A549** cells is influenced by both the linear and quadratic components of radiation damage. A value of $\boldsymbol{A = 0.046}$ suggests a relatively modest low-dose linear killing component. By contrast, $\boldsymbol{B = 0.0329}$ is positive and its confidence interval remains above zero, which suggests that the quadratic component is more clearly supported by the data and that cell killing becomes more pronounced as dose increases.

The high $\boldsymbol{R^2}$ squared value of **0.994** and the low scatter around the fitted curve indicate that the linear-quadratic model describes this dataset adequately, although the confidence interval for $\boldsymbol{A}$ suggests that the linear component is estimated with less certainty than the quadratic component.

References:

(1) Buch, K., Peters, T., Nawroth, T., Sänger, M., Schmidberger, H. and Langguth, P., 2012. Determination of cell survival after irradiation via clonogenic assay versus multiple MTT Assay-A comparative study. *Radiation oncology*, *7*(1), p.1.