Title

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pkexamine — Calculate pharmacokinetic measures

Description

`pkexamine` calculates pharmacokinetic measures from time-and-concentration subject-level data. `pkexamine` computes and displays the maximum measured concentration, the time at the maximum measured concentration, the time of the last measurement, the elimination time, the half-life, and the area under the concentration-time curve (AUC). Three estimates of the area under the concentration-time curve from 0 to infinity ($\text{AUC}_{0,\infty}$) are also calculated.

`pkexamine` is one of the pk commands. Please read [R] **pk** before reading this entry.

Quick start

Pharmacokinetic measures for concentrations `y` at times `tvar` where `idvar` $= 4$

```
pkexamine tvar y if idvar==4
```

As above, but use trapezoidal rule to calculate $\text{AUC}_{0,t_{\max}}$

```
pkexamine tvar y if idvar==4, trapezoid
```

Plot concentration-time curve where `idvar` $= 2$

```
pkexamine tvar y if idvar==2, graph
```

As above, and save graph as `mygraph`

```
pkexamine tvar y if idvar==2, graph saving(mygraph)
```

Menu

Statistics > Epidemiology and related > Other > Pharmacokinetic measures

Syntax

```
pkexamine time concentration [if] [in] [, options]
```

options	Description
Main	
`fit(#)`	use # points to estimate $AUC_{0,\infty}$; default is `fit(3)`
`trapezoid`	use trapezoidal rule; default is cubic splines
`graph`	graph the AUC
`line`	graph the linear extension
`log`	graph the log extension
`exp(#)`	plot the exponential fit for the $AUC_{0,\infty}$
AUC plot	
cline_options	affect rendition of plotted points connected by lines
marker_options	change look of markers (color, size, etc.)
marker_label_options	add marker labels; change look or position
Add plots	
`addplot(`*plot*`)`	add other plots to the generated graph
Y axis, X axis, Titles, Legend, Overall	
twoway_options	any options other than `by()` documented in [G-3] ***twoway_options***

`by` is allowed; see [D] **by**.

Options

Main

`fit(#)` specifies the number of points, counting back from the last measurement, to use in fitting the extension to estimate the $AUC_{0,\infty}$. The default is `fit(3)`, or the last three points. This value should be viewed as a minimum; the appropriate number of points will depend on your data.

`trapezoid` specifies that the trapezoidal rule be used to calculate the AUC. The default is cubic splines, which give better results for most functions. When the curve is irregular, `trapezoid` may give better results.

`graph` tells `pkexamine` to graph the concentration-time curve.

`line` and `log` specify the estimates of the $AUC_{0,\infty}$ to display when graphing the $AUC_{0,\infty}$. These options are ignored, unless they are specified with the `graph` option.

`exp(#)` specifies that the exponential fit for the $AUC_{0,\infty}$ be plotted. You must specify the maximum time value to which you want to plot the curve, and this time value must be greater than the maximum time measurement in the data. If you specify 0, the curve will be plotted to the point at which the linear extension would cross the x axis. This option is not valid with the `line` or `log` option and is ignored, unless the `graph` option is also specified.

AUC plot

cline_options affect the rendition of the plotted points connected by lines; see [G-3] ***cline_options***.

marker_options specify the look of markers. This look includes the marker symbol, the marker size, and its color and outline; see [G-3] ***marker_options***.

marker_label_options specify if and how the markers are to be labeled; see [G-3] ***marker_label_options***.

Add plots

`addplot(`*plot*`)` provides a way to add other plots to the generated graph. See [G-3] ***addplot_option***.

Y axis, X axis, Titles, Legend, Overall

twoway_options are any of the options documented in [G-3] ***twoway_options***, excluding `by()`. These include options for titling the graph (see [G-3] ***title_options***) and for saving the graph to disk (see [G-3] ***saving_option***).

Remarks and examples

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`pkexamine` computes summary statistics for a given patient in a pharmacokinetic trial. If `by` *idvar*`:` is specified, statistics will be displayed for each subject in the data.

▷ Example 1

Chow and Liu (2009, 13) present data on a study examining primidone concentrations versus time for a subject over a 32-hour period after dosing.

```
. use http://www.stata-press.com/data/r15/auc
. list, abbrev(14)
```

	id	time	concentration
1.	1	0	0
2.	1	.5	0
3.	1	1	2.8
4.	1	1.5	4.4
5.	1	2	4.4
6.	1	3	4.7
7.	1	4	4.1
8.	1	6	4
9.	1	8	3.6
10.	1	12	3
11.	1	16	2.5
12.	1	24	2
13.	1	32	1.6

We use pkexamine to produce the summary statistics:

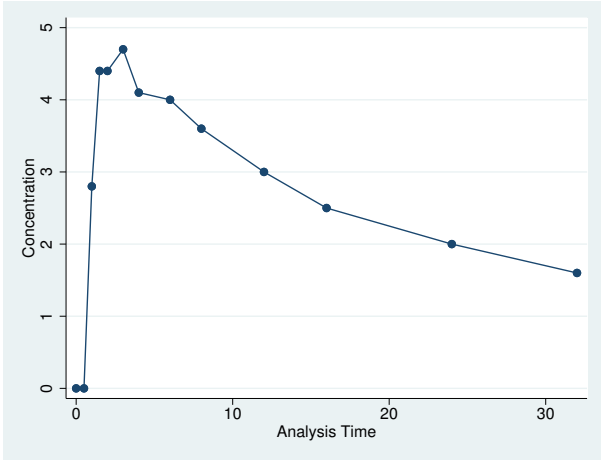
```
. pkexamine time conc, graph
```

```
                                  Maximum concentration =       4.7
                              Time of maximum concentration =         3
                            Time of last observation (Tmax) =        32
                                        Elimination rate =    0.0279
                                               Half life =   24.8503
```

Area under the curve

AUC [0, Tmax]	AUC [0, inf.) Linear of log conc.	AUC [0, inf.) Linear fit	AUC [0, inf.) Exponential fit
85.24	142.603	107.759	142.603

Fit based on last 3 points.



The maximum concentration of 4.7 occurs at time 3, and the time of the last observation (Tmax) is 32. In addition to the AUC, which is calculated from 0 to the maximum value of time, pkexamine also reports the area under the curve, computed by extending the curve with each of three methods: a linear fit to the log of the concentration, a linear regression line, and a decreasing exponential regression line. See *Methods and formulas* for details on these three methods.

By default, all extensions to the AUC are based on the last three points. Looking at the graph for these data, it seems more appropriate to use the last seven points to estimate the $\text{AUC}_{0,\infty}$:

```
. pkexamine time conc, fit(7)
```

```
                                  Maximum concentration =       4.7
                              Time of maximum concentration =         3
                            Time of last observation (Tmax) =        32
                                        Elimination rate =    0.0349
                                               Half life =   19.8354
```

Area under the curve

AUC [0, Tmax]	AUC [0, inf.) Linear of log conc.	AUC [0, inf.) Linear fit	AUC [0, inf.) Exponential fit
85.24	131.027	96.805	129.181

Fit based on last 7 points.

This approach decreased the estimate of the $\text{AUC}_{0,\infty}$ for all extensions. To see a graph of the $\text{AUC}_{0,\infty}$ using a linear extension, specify the `graph` and `line` options.

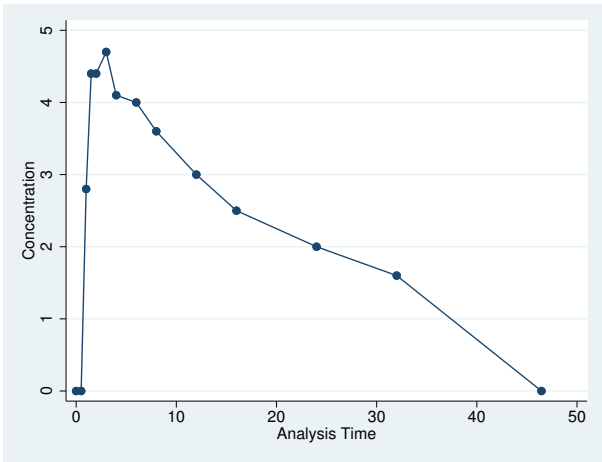
```
. pkexamine time conc, fit(7) graph line
```

```
                                  Maximum concentration =       4.7
                        Time of maximum concentration =         3
                      Time of last observation (Tmax) =        32
                                  Elimination rate =    0.0349
                                         Half life =   19.8354

Area under the curve
```

AUC [0, Tmax]	AUC [0, inf.) Linear of log conc.	AUC [0, inf.) Linear fit	AUC [0, inf.) Exponential fit
85.24	131.027	96.805	129.181

```
Fit based on last 7 points.
```



Stored results

`pkexamine` stores the following in `r()`:

Scalars

`r(auc)`	area under the concentration curve
`r(half)`	half-life of the drug
`r(ke)`	elimination rate
`r(tmax)`	time at last concentration measurement
`r(cmax)`	maximum concentration
`r(tomc)`	time of maximum concentration
`r(auc_line)`	$\text{AUC}_{0,\infty}$ estimated with a linear fit
`r(auc_exp)`	$\text{AUC}_{0,\infty}$ estimated with an exponential fit
`r(auc_ln)`	$\text{AUC}_{0,\infty}$ estimated with a linear fit of the natural log

Methods and formulas

Let i index the observations sorted by time, let k be the number of observations, and let f be the number of points specified in the `fit(#)` option.

The $\text{AUC}_{0,t_{\max}}$ is defined as

$$\text{AUC}_{0,t_{\max}} = \int_0^{t_{\max}} C_t dt$$

where C_t is the concentration at time t. By default, the integral is calculated numerically using cubic splines. However, if the trapezoidal rule is used, the $\text{AUC}_{0,t_{\max}}$ is given as

$$\text{AUC}_{0,t_{\max}} = \sum_{i=2}^{k} \frac{C_{i-1} + C_i}{2} (t_i - t_{i-1})$$

The $\text{AUC}_{0,\infty}$ is the $\text{AUC}_{0,t_{\max}}$ + $\text{AUC}_{t_{\max},\infty}$, or

$$\text{AUC}_{0,\infty} = \int_0^{t_{\max}} C_t dt + \int_{t_{\max}}^{\infty} C_t dt$$

When using the linear extension to the $\text{AUC}_{0,t_{\max}}$, the integration is cut off when the line crosses the x axis. The log extension is a linear extension on the log concentration scale. The area for the exponential extension is

$$\text{AUC}_{0,\infty} = \int_{t_{\max}}^{\infty} e^{-(\beta_0 + t\beta_1)} dt = -\frac{e^{-(\beta_0 + t_{\max}\beta_1)}}{\beta_1}$$

The elimination rate K_{eq} is the negative of the slope from a linear regression of log concentration on time fit to the number of points specified in the `fit(#)` option:

$$K_{\text{eq}} = -\frac{\sum_{i=k-f+1}^{k} \left(t_i - \bar{t}\right) \left(\ln C_i - \overline{\ln C}\right)}{\sum_{i=k-f+1}^{k} \left(t_i - \bar{t}\right)^2}$$

The half-life is

$$t_{\text{half}} = \frac{\ln 2}{K_{\text{eq}}}$$

Reference

Chow, S.-C., and J.-P. Liu. 2009. *Design and Analysis of Bioavailability and Bioequivalence Studies.* 3rd ed. Boca Raton, FL: Chapman & Hall/CRC.

Also see

[R] **pk** — Pharmacokinetic (biopharmaceutical) data