

```

%MACRO BinomCL(s,n,direction=1,conf=0.95,sides=1);
/*****
/* Calculate "exact" (Clopper-Pearson) binomial confidence limit
/*
/* Parameters:
/*   s          number of "successes" observed in the sample
/*   n          sample size
/*   direction   negative for lower confidence limit, nonnegative for upper (default is upper confidence limit)
/*   conf        confidence level as a decimal fraction (default is 0.95 for a 95% confidence limit)
/*   sides       1 for 1-sided, 2 for 2-sided, anything else generates a missing value (default is 1)
/*               2-sided inverts an equal-tailed test (i.e. not a "shortest" non-randomized interval)
/*               e.g. %BinomCL(x,n,conf=0.90,sides=2) = %BinomCL(x,n,conf=0.95,sides=1)
/*
/* Named parameters direction & sides must be constants if given,
/* but s, n, & conf can be SAS variables or even formulas
/*
/* Structured to allow %BinomCL to be used like a function within a SAS expression, such as UCL = %BinomCL(x,n);
/* Optional parameters must be named in the call and can be given in any order, as in %BinomCL(x,n,conf=0.90)
/* All variables are local, so there is no restriction on variable names in the calling program
/*
/* Parentheses around subtracted macro variables handle the possibility that the variable contains an expression
/* BETAINV does not support degenerate distributions with one zero parameter
/*   (lower CL with s=0 or upper CL with s=n); IFN() forces correct confidence limit for these cases,
/*   but the log will contain a NOTE about an "invalid" argument (IFN() executes both branches)
/*
/* Formulas based on Hahn & Meeker "Statistical Intervals", p.104, but simplified to use BETAINV instead of FINV
/*   e.g. Computers in Biol. & Med. 22:351-361,1992 and Metron 54(1):153-180,1996
/* Programmed by Jerry W. Lewis, PhD          3 Jan 2008
/*
/* Since no pivotal quantity exists, Clopper-Pearson and "shortest" intervals are "exact" in the sense that
/* the coverage probability is at least &conf for any parameter, but they are "conservative" in the sense that
/* for some parameters the coverage probability is (possibly much) higher.
/* Agresti & Coull (Am.Statist. 52:119-126 1998) argue for approximate intervals that only achieve the stated
/* coverage on average. Such an approach seems to require either:
/*   - a distribution on the parameter space (in which case fully Bayesian methods seem more appropriate), or
/*   - a hope that nature has not perversely given you a parameter with below average coverage.
/*   Such a hope seems closer to wishful thinking than considered opinion.
/* Therefore "exact" intervals seem to be more defensible in the frequentist context.
*****/
%IF %SYSEVALF(&sides=1,BOOLEAN) OR %SYSEVALF(&sides=2,BOOLEAN) %THEN %DO;
  %IF %EVAL(&sides)=2 %THEN %LET conf = 1-(1-(&conf))/2;
  %IF %SYSEVALF(&direction<0,BOOLEAN) %THEN /* lower confidence limit */
    IFN(&s=0,0,BETAINV(1-(&conf),&s,&n-(&s)+1));
  %ELSE /* upper confidence limit */
    IFN(&s=&n,1,BETAINV(&conf,&s+1,&n-(&s)));
%END;
%ELSE .
%MEND BinomCL;

```