**Supplemental Appendix 1: SAS Code**

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\* CUSUM Macros to be called in individual state program calls. \*

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 Cusum Macros

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/\* Split data into 5 year chunks. Drop off one month and add one month

 for each. i.e.

 Jan 2007 - Dec 2012 --> Feb 2007 - Jan 2013 --> Mar 2007 - Feb 2013 \*/

%macro dataSplit(dataset=,program=); /\*Open macro\*/

 /\*Initialize starting values for month and year variables\*/

 %let startyear = 2007;

 %let endyear = 2012; /\*Change depending on length of time window\*/

 %let startmonth = 1;

 %let endmonth = 1;

 /\*Begin loop to output multiple data sets

 The end value for i must be adjusted if the time frame for the

 moving window is changed \*/

 %do i = 1 %to 48;

 /\*Create variables to use as checks against monthDate var\*/

 %let startcheckdate = mdy(&startmonth,1,&startyear);

 %let endcheckdate = mdy(&endmonth,1,&endyear);

 /\*Data step to create subset\*/

 data pr&program.&i;

 set &dataset;

 if &startcheckdate <= monthDate <= &endcheckdate then output;

 run;

 data pr04&i;

 set pr04&i;

 time\_cat+1;

 if time\_cat > 36 then time\_cat2+1;\*allows for join point;

 else time\_cat2 = 0;

 run;

 /\*Increment month and year variables -

 If the month is already 12, it is reset to 1 and the year is

 incremented. Otherwise, the month is incremented \*/

 %if &startmonth = 12 %then %do;

 %let startmonth = 1;

 %let startyear = %eval(&startyear+1);

 %end; /\*End if-do\*/

 %else %let startmonth = %eval(&startmonth+1);

 %if &endmonth = 12 %then %do;

 %let endmonth = 1;

 %let endyear = %eval(&endyear+1);

 %end; /\*End if-do\*/

 %else %let endmonth = %eval(&endmonth+1);

 %end; /\*End do loop\*/

%mend; /\*Close macro\*/

/\* create Macro vars for Cusum graph output \*/

%let time1 = Jan 2007 to Jan 2012;

%let time2 = Feb 2007 to Feb 2012;

%let time3 = Mar 2007 to Mar 2012;

%let time4 = Apr 2007 to Apr 2012;

%let time5 = May 2007 to May 2012;

%let time6 = Jun 2007 to Jun 2012;

%let time7 = Jul 2007 to Jul 2012;

%let time8 = Aug 2007 to Aug 2012;

%let time9 = Sep 2007 to Sep 2012;

%let time10 = Oct 2007 to Oct 2012;

%let time11 = Nov 2007 to Nov 2012;

%let time12 = Dec 2007 to Dec 2012;

%let time13 = Jan 2008 to Jan 2013;

%let time14 = Feb 2008 to Feb 2013;

%let time15 = Mar 2008 to Mar 2013;

%let time16 = Apr 2008 to Apr 2013;

%let time17 = May 2008 to May 2013;

%let time18 = Jun 2008 to Jun 2013;

%let time19 = Jul 2008 to Jul 2013;

%let time20 = Aug 2008 to Aug 2013;

%let time21 = Sep 2008 to Sep 2013;

%let time22 = Oct 2008 to Oct 2013;

%let time23 = Nov 2008 to Nov 2013;

%let time24 = Dec 2008 to Dec 2013;

%let time25 = Jan 2009 to Jan 2014;

%let time26 = Feb 2009 to Feb 2014;

%let time27 = Mar 2009 to Mar 2014;

%let time28 = Apr 2009 to Apr 2014;

%let time29 = May 2009 to May 2014;

%let time30 = Jun 2009 to Jun 2014;

%let time31 = Jul 2009 to Jul 2014;

%let time32 = Aug 2009 to Aug 2014;

%let time33 = Sep 2009 to Sep 2014;

%let time34 = Oct 2009 to Oct 2014;

%let time35 = Nov 2009 to Nov 2014;

%let time36 = Dec 2009 to Dec 2014;

%let time37 = Jan 2010 to Jan 2015;

%let time38 = Feb 2010 to Feb 2015;

%let time39 = Mar 2010 to Mar 2015;

%let time40 = Apr 2010 to Apr 2015;

%let time41 = May 2010 to May 2015;

%let time42 = Jun 2010 to Jun 2015;

%let time43 = Jul 2010 to Jul 2015;

%let time44 = Aug 2010 to Aug 2015;

%let time45 = Sep 2010 to Sep 2015;

%let time46 = Oct 2010 to Oct 2015;

%let time47 = Nov 2010 to Nov 2015;

%let time48 = Dec 2010 to Dec 2015;

\*etc…as more data are available

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 CUSUM

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/\* set number of months to include in regression for detrending/projection \*/

%let Lag = 60;

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

 Begin Cusum Shewhart Macro / Code

 detrending macro that runs the genmod models and outputs the residuals

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%macro detrend; \* an alternative way to detrend (regression), but seems can simple difference as above;

data bll\_out\_d;

 set bll\_out;

run; \*create new data set: bll\_out\_d;

data v\_out;

 \_type\_ = .;

 \_freq\_ = .;

 meanV = .;

 medianV = .;

run;

%do NN = 61 %to 61; \*start with NN= 11 so have enough data points for regression;

data regr;

 set bll\_out; \*always go back to original data set;

 ysave = pct;

 if \_n\_ le &NN and \_n\_ ge &NN - &Lag;

 if \_n\_ = &NN then pct = .;

 \*\* --- create linear spline variables with knot q2 --- \*\*;

 Mont1=month;

 mont3=0;

 if month ge 3 then mont3= month -3;

 mont6=0;

 if month ge 6 then mont6= month -6;

 mont9=0;

 if month ge 9 then mont9= month -9;

run;

/\* Run autoregression to use in predicting one month ahead \*/

ods output ParameterEstimates = parms;

ods output FitSummary = fitSum;

proc autoreg data=regr;

 model pct = time\_cat time\_cat2 mont1 mont3 mont6 mont9 / method=ml;

 restrict 12\*mont1 + 10\*mont3 + 7\*mont6 + 4\*mont9 = 0;

 output alphacli=0.05 out=reg\_out r=resid p=yhat pm=trendhat

 residualM=residM lcl=lcl ucl=ucl;

run;

/\* Transpose output parameter estimates \*/

proc transpose data=parms out=parms\_transp;

 var estimate;

run;

/\* rename output parameter estimates \*/

data parms;

 set parms\_transp;

 rename col1=int col2=beta col3=beta2;

 keep col1 col2 col3;

run;

/\* Get degrees of freedom and output to macro var for use in

 calculating V below \*/

data df;

 set fitsum;

 if label2= "DFE";

 keep nValue2;

 rename nValue2=dfe;

 call symput('df',nValue2);

run;

/\* Save MSE for each run \*/

data fitsum;

 set fitsum;

 if label1 = "MSE";

 keep nValue1;

 rename nValue1=mse;

run;

/\* calculate v \*/

data reg\_out;

 set reg\_out;

 v = ((ucl-lcl)/(2\*tinv(.975,&df)))\*\*2;

 resid\_save = ysave-yhat;

run;

data bll\_out\_d;

 set reg\_out;

 rename resid\_save = dtpct;

 keep yhat monthDate numGE5 pct total time\_cat time\_cat2 month dpct

 ma ysave v resid\_save;

run;

/\* calculate mean and median of V and output to data set \*/

proc means data=work.reg\_out noprint;

 var v;

 output out=v mean=meanV median=medianV;

run;

/\* Append mean MSE from this run to previous runs; append mean and

 median V from this run to previous runs \*/

proc datasets nolist;

 append base=fitsum\_out data=fitsum;

 append base=v\_out data=v;

run;

proc delete data=parms;

run;

proc delete data=regr;

run;

%end;

run;

%mend; /\*End detrend macro\*/

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 Begin macro to call detrend macro and output shewhart/cusum charts

 multiple times, one for each 3 year chunk of data.

 Macro call requires a start number and end number corresponding

 to data sets created above.

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%macro cusumMac(start=,end=);

%do c = &start %to &end;

data bll\_out;

 set work.pr04&c;

run;

data bll\_out;

 set bll\_out;

 if \_n\_ > 0 then do;

 dpct = pct - lag1(pct); \*detrend, before combining months (differencing method);

 ma = (pct + lag1(pct) + lag2(pct))/3; \*ma: just for plotting;

 end; \*if;

 if \_n\_ = 1 then dpct=pct;

run;

/\*\*\*\*\* Call detrend macro \*\*\*\*\*/

%detrend;

data bll\_out;

 set bll\_out\_d;

 pcts = pct; \*save original percent for simple shewhart;

 \*pct = dpct; \*<--- over-write orginal pct, with dpct, ONLY if want to use differencing to detrend;

 pct =dtpct; \*<--- over-write orginal pct, with dtpct, ONLY if want to use regression for detrend;

run;

proc sort data=bll\_out;

 by time\_cat;

run;

data v\_out;

 set v\_out;

 if meanV ne .;

 keep meanV medianV;

run;

/\* calculate mean of MSE output above \*/

proc means data=work.fitsum\_out n sum noprint;

 output out=means sum=sum n=n;

run;

/\* Calculate mean of median V calculated above \*/

proc means data=work.v\_out n mean noprint;

 var medianV;

 output out=meansV sum=sum n=n;

run;

/\* Set standard deviation of the MSEs as macro var to use

 in CUSUM call below IF USING MSE\*/

data means;

 set means;

 stdev = sqrt(sum/n);

 call symput('sigma',stdev);

run;

/\* Set standard deviation of V as macro var to use in

 CUSUM call below IF USING V (as in this version ) \*/

data meansV;

 set meansV;

 stdev = sqrt(sum/n);

 call symput('sigmaV',stdev);

run;

data sigma;

 sigma = &sigma;

run;

data sigmaV;

 sigmaV = &sigmaV;

run;

/\* Save MSE sigma and V sigma for reviewing \*/

proc datasets nolist;

 append base=sigma\_out data=sigma;

 append base=sigmaV\_out data=sigmaV;

run;

/\* Call cusum \*/

proc cusum data=bll\_out;

 xchart pct\*time\_cat /

 nochart

 mu0=0.0 /\* target percent over 5 mcg/dL \*/

 sigma0 = &sigmaV

 delta=3 /\* shift to be detected \*/

 h=3.0 /\* h is the decision interval, usually set between 4 and 5 \*/

 k=1.0 /\* k is the reference interval, usually set to the delta/2 but it usually needs to be tested by the user \*/

 scheme=onesided

 outtable = Tabcusum

 ( drop = \_var\_ \_subn\_ \_subx\_ \_exlim\_

 rename = ( \_cusum\_ = \_subr\_ \_h\_ = \_uclr\_ ) )

 ;

run;

/\* Call shewhart \*/

proc shewhart data=bll\_out;

 irchart pct\*time\_cat/

 nochart

 outtable = Tabxscht

 ( drop = \_subr\_ \_lclr\_ \_r\_ \_uclr\_ );

run;

data taball;

 merge Tabxscht Tabcusum; by time\_cat;

 \_lclr\_=0.0;

 \_r\_ = 0.5 \* \_uclr\_;

run;

ods graphics off;

symbol v=dot color=red h=1.8 pct;

/\*title 'Combined Shewhart-Cusum Chart for Residuals by Month and Std Dev Chart-Sinusoidal Pattern';\*/

proc shewhart table=taball;

 irchart pct\*time\_cat/

 split = '/'

 noctl2

 ;

 label \_subi\_ = 'Shewhart/Cusum'

 time\_cat= 'Month Range'

 ;

title 'Shewhart Individual and Cusum Chart for Proportion >= 5 by Month';

title2 " &time&c ";

\*format time\_cat time\_catf.;

run; title; title2;

%end; /\*end do loop\*/

%mend;