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Utilizing SAS® to Estimate Rates of Disease from Nationally Representative Databases

Jessica M. Rudd MPH, PhD Student in Analytics and Data Science, College of Science and Mathematics, Kennesaw State University

ABSTRACT

One of the research goals in public health is to estimate the burden of diseases among the US population. We describe burden of disease by analyzing the statistical association of various diseases with: hospitalizations, emergency department (ED) visits, ambulatory/outpatient (doctors' office) visits, and deaths. In this short paper, we discuss the use of large, nationally representative databases, such as those offered by the National Center for Health Statistics (NCHS) or the Agency for Healthcare Research and Quality (AHRQ), to produce reliable estimates of disease for studies. In this example, we use SAS® and SAS®-callable SUDAAN® to analyze the Nationwide Emergency Department Sample (NEDS), offered by AHRQ, to estimate Hand, Foot, and Mouth Disease (HFMD) associated emergency department (ED) visits in children less than 5 years old.

INTRODUCTION

The Nationwide Emergency Department Sample (NEDS) is an annual database started in 2006 that includes a 20% stratified sample of hospital based emergency departments from 30 states. "The NEDS is the largest all-payer emergency department database in the United States" and accounts for approximately 135 million ED visits per year. The database design has remained relatively unchanged since its inception so multi-year studies are convenient and SAS® programs can be reused year-to-year. Additionally, design variables are already provided with the datasets (HCUP).

SUDAAN® VS. SAS SURVEY PROCEDURES?

Why did I use SAS®-callable Sudaan® to estimate rates of disease rather than the available SAS® survey procedures, SURVEYMEANS? Briefly, Sudaan® is still widely considered the industry standard for analysis of complex survey designs. Until recent years, SAS® statistical procedures did not take into account design properties of complex samples and would assume a simple random sample design. This can generally lead to underestimation of the variance. While SAS® has introduced in recent versions the SURVEYMEANS AND SURVEYREG procedures to account for complex designs, adjustments have to be made to several SAS options in these procedures to produce identical results as the SUDAAN procedures. Using SAS® survey procedures will produce the same weighted estimates.

STEPS FOR PRODUCING DISEASE ESTIMATES

The following steps create analysis variables and datasets, and produce weighted estimates of HFMD-associated ED visits among children less than 5 years old (see Appendix for full code and output):

1. Import core datasets:
   - Yearly datasets available from AHRQ with a data use agreement
   - Text files are converted to SAS files before analysis

```
%MACRO LOOP;
   %LOCAL I;
   %DO I=2006 %TO 2012; /* Update here when new datasets become
   available*/

LIBNAME NEDS '\\cdc\project\NCIRD_DVD_EB_DATA_1\hcup\neds\data';

DATA NEDS_&I._CORE (compress=binary);
```

```
   SET NEDS.NEDS_&I._CORE;
   RUN;

PROC CONTENTS DATA=NEDS_&I._CORE; *** Review contents of dataset;
   RUN;

   %END;
   %MEND LOOP;
%LOOP;
QUIT;
```

2. Create analysis variable:

   - The KID observations include up to 15 ICD-9-CM codes per record so several different variables were created for different study needs
   - An array is used to create the hand, foot, and mouth disease analysis variables:
     - *HFM* = HFMD diagnosis coded in any of the 15 ICD-9-CM variable positions
     - *HFM_F*= HFMD diagnosis coded in the first ICD-9-CM variable

```
%MACRO LOOP;
   %LOCAL I;
   %DO I=2006 %TO 2012;

DATA HFM_&I (compress=binary);
   SET NEDS_&I._CORE;
   ARRAY DIAGNOSIS (15) $ DX1-DX15;
         DO i=1 to 15;
               IF SUBSTR(DIAGNOSIS(i),1,4) IN('0743')THEN DO;
               HFM=1;
               IF I=1 THEN HFM_F=1; ELSE HFM_F=0;
         END;
   END;
   /*Recode gender variable*/
   IF FEMALE=0 THEN SEX=1;else;
   IF FEMALE=1 THEN SEX=2;
   RUN;
   %END;
   %MEND LOOP;
%LOOP;
QUIT;
```

3. Combine years of data and subset on subpopulation of interest in order to control size and processing of data:

```
DATA HFM_06_12;
   SET HFM_2006 HFM_2007 HFM_2008 HFM_2009 HFM_2010 HFM_2011 HFM_2012;
   IF HFM=1 AND AGE LT 5 THEN OUTPUT;
RUN;
***DELETE WORK DATASETS TO AVOID RUNNING OUT OF RESOURCES IN SAS ***;
%MACRO LOOP;
   %LOCAL I;
   %DO I=2006 %TO 2012;
   PROC DATASETS;
   DELETE HFM_&I NEDS_&I._CORE;
   RUN;
```

```
   %END;
   %MEND LOOP;
%LOOP;
QUIT;
```

4. Create analysis formats and rate denominator:
   - Format labels for analysis variables
   - Set denominator for rate calculations

```
PROC FORMAT;
   VALUE SEX 1='MALE' 2='FEMALE';
   VALUE AGEGRP 1='LT 1' 2='1-4';
   VALUE REGION 1='NORTHEAST' 2='MIDWEST' 3='SOUTH' 4='WEST';
   VALUE MONTHF 1='JAN' 2='FEB' 3='MAR' 4='APR' 5='MAY' 6='JUN' 7='JUL' 8=
   'AUG' 9='SEP' 10='OCT' 11='NOV' 12='DEC';
   RUN;

%LET DENOM=100000; *** Denominator for rates is 100,000 person visits***;
```

5. Create hospital weights table from the hospital weights file included with year NEDS datasets:

```
%MACRO LOOP;
   %LOCAL I;
   %DO I=2006 %TO 2012;

PROC SQL;
   CREATE TABLE HOSP&I AS
   SELECT YEAR,HOSP_ED,HOSP_CONTROL,HOSP_TRAUMA,HOSP_REGION,
   HOSP_UR_TEACH,NEDS_STRATUM,DISCWT
   FROM NEDS.NEDS_&I._HOSPITAL
   ORDER BY YEAR,HOSP_ED;
   %END;
   %MEND LOOP;
   %LOOP;
   QUIT;
```

6. Create analysis datasets based on required study criteria:
   - Combine hospital weights datasets and merge with subpopulation dataset
   - Create dummy records for the hospital strata that are not captured in the subpopulation, i.e. strata without records of HFMD in children less than 5

```
*********************************************************
****** 6a. Combine hospital weights files     *****
*********************************************************;

DATA HOSPWTS;
   SET HOSP2006 HOSP2007 HOSP2008 HOSP2009 HOSP2010 HOSP2011 HOSP2012;
   RUN;

*********************************************************
****** 6b. Create analysis dataset based on study criteria*
*********************************************************;

OPTIONS BUFNO=500 BUFSIZE=32k;
```

```
DATA HFM_NEDS_ANALYSIS(SGIO=YES) ;
MERGE HFM.HFM_06_12 (IN=C SGIO=YES DROP=KEY_ED AWEEKEND DQTR CHRON1-
CHRON15 INTENT_SELF_HARM DXCCS1-DXCCS15 E_CCS1-E_CCS4 I NEDS_STRATUM)
HOSPWTS (IN=B RENAME=(HOSP_REGION=REGION));
BY YEAR HOSP_ED;

*this adds dummy records for any strata that might not be captured in
the subset, to ensure correct variances;
IF B=1 AND (C NE 1) THEN DO;
HFM=0;
DISCWT=0.00000001;
      END;

NEW_STRAT=NEDS_STRATUM||'-'||LEFT(YEAR);
NEW_STRAT2=YEAR*10000000+NEDS_STRATUM;

IF AGE=0 THEN AGEGRP=1; ELSE
IF AGE IN (1,2,3,4) THEN AGEGRP=2;

IF HFM_F=. THEN HFM_F=0;

FORMAT YEAR 5. SEX SEX. REGION REGION. AMONTH MONTHF. AGEGRP AGEGRP.;
RUN;

PROC SORT DATA=HFM_NEDS_ANALYSIS;
BY NEW_STRAT2 HOSP_ED;
RUN;
```

7. Create census analysis dataset for use with rate calculations:

   - I used the bridged race census data files available from the National Center for Health Statistics (CDC, 2016)

```
LIBNAME CEN '\\cdc\project\NCIRD_DVD_EB_DATA_1\census\bridged_race\data';
DATA CEN;
SET CEN.br90_13_B (KEEP=YEAR SEX AGE POP
STATE);
      IF 2006<=YEAR<=2012;
      DIED=2;

FORMAT SEX SEX.;

LABEL POP='AGE GROUP
CENSUS';
IF STATE
IN(23,33,50,25,44,09,36,34,42) THEN REGION=1;
IF STATE IN
(39,18,17,26,55,27,19,29,38,46,31,20) THEN REGION=2;
IF STATE
IN(10,24,11,51,54,37,45,13,12,21,47,01,28,05,22,40,48)
THEN REGION=3;
IF STATE
IN(30,16,56,08,35,04,49,32,53,41,06,02,15) THEN REGION=4;

IF AGE GT 4 THEN DELETE;

RENAME POP=POP2;
```

```
RUN;


DATA CEN;
SET CEN;
IF AGE=0 THEN AGEGRP=1;
IF AGE IN (1,2,3,4) THEN AGEGRP=2;
IF SEX=. THEN SEX=1;
FORMAT AGEGRP AGEGRP.;
RUN;

PROC FREQ DATA=CEN;
TABLES YEAR SEX AGEGRP AGE REGION ;
FORMAT YEAR 5. SEX SEX. REGION REGION. ;
RUN;

PROC SUMMARY NWAY MISSING;

CLASS YEAR SEX AGEGRP REGION DIED;
VAR POP2;

OUTPUT OUT=CENSUS SUM=;

RUN;
```

8. Create output datasets with weighted estimates of disease:

   - Sudaan® crosstab procedure used to create summary tables of *HFM* unweighted cases, weighted cases, and standard errors by age group and year, sex and year, region and year

```
options mprint;
DATA CAT;

INPUT CAT $ @@;
CARDS;

HFM
;
RUN;

DATA _NULL_;
SET CAT END=LAST;
CALL SYMPUT('CAT'||LEFT(PUT(_N_,3.)),CAT);
IF LAST THEN CALL SYMPUT('COUNT',_N_);
RUN;

%MACRO LOOP;
%LOCAL I;
%DO I=1 %TO &COUNT;
%LET TI=%CMPRES(&&CAT&I);
ODS RTF
FILE="\\cdc.gov\private\L317\icj2\Studies\HFM\&ti._rates_&sysdate..rtf"
STYLE=RTF STARTPAGE=NO BODYTITLE SASDATE;

TITLE "Hand, Foot and Mouth Disease ED Visits,Children under 5 yrs,
CATEGORY=&TI (All diagnoses), US, 2006-2012, NEDS";
      PROC CROSSTAB DATA=HFM_NEDS_ANALYSIS FILETYPE=SAS DESIGN=WR;
      WEIGHT DISCWT;
```

```
        SUBPOPN &TI=1;
        NEST NEW_STRAT2 HOSP_ED/ MISSUNIT;
        CLASS YEAR SEX AGEGRP REGION /INCLUDE=MISSING;
    TABLES SEX AGEGRP REGION year YEAR*(SEX AGEGRP REGION);
    SETENV LEFTMGN=1;
        RTITLE "Hand, Foot and Mouth ED Visits, Children under 5 yrs,
        CATEGORY=&TI (All diagnoses), US [NEDS], 2006-2012";
    PRINT NSUM WSUM COLPER ROWPER SEWGT SECOL SETOT;
        OUTPUT NSUM="UNWEIGHTED CASES" WSUM="WEIGHTED
        CASES" SEWGT="STANDARD ERROR"/FILENAME="WORK.VAR97"
    FILETYPE=SAS REPLACE;
    FORMAT YEAR 4. SEX SEX. AGEGRP AGEGRP.;
        QUIT;
```

9. Calculate rates of hand, foot, and mouth disease associated hospitalizations:

   - SQL used to combine Sudaan summary tables with census analysis tables

```
DATA TOTHOSPS;
   SET VAR97;
   IF YEAR=0 AND SEX=-2 AND AGEGRP=0 AND REGION=-2;
   KEEP WSUM SEWGT;
   RUN;
PROC SQL;
   CREATE TABLE TOTCEN AS
   SELECT SUM(POP2) AS POP2 LABEL='CENSUS TOTAL'
   FROM CENSUS;

DATA ALL;
   MERGE TOTHOSPS TOTCEN;
   %MACRO RATECI;
   RATE=(WSUM/POP2)*&DENOM;

   raterse1=(RATE*(SEWGT/WSUM));

   lci1=(RATE-(1.96*raterse1));
   uci1=(RATE+(1.96*raterse1));

   LABEL RATE="HOSPS/&DENOM" WSUM ='HOSPS' LCI1='LOWER 95% CI' UCI1='UPPER
   95% CI';
   FORMAT RATE LCI1 UCI1 10.1 WSUM SEWGT COMMA10. POP2 COMMA12.;
   %MEND RATECI;
   %RATECI;
   RUN;

   PROC PRINT NOOBS LABEL;
   TITLE2 "TOTAL RATE";
   RUN;

   **********************
   ****** BY YEAR   *****
   **********************;
   DATA TOTHOSPS;
   SET VAR97;
   IF YEAR>0 AND SEX=0 AND AGEGRP=-2 AND REGION=-2;
   KEEP YEAR WSUM SEWGT;
   RUN;
```

```
PROC SQL;
CREATE TABLE TOTCEN AS
SELECT YEAR, SUM(POP2) AS POP2 LABEL='CENSUS TOTAL'
FROM CENSUS
GROUP BY YEAR;

DATA ALL;
MERGE TOTHOSPS TOTCEN;
BY YEAR;
%RATECI;
RUN;

PROC PRINT NOOBS LABEL;
TITLE2 "RATE BY YEAR";
RUN;

ODS RTF CLOSE;
%END;
%MEND LOOP;
%LOOP;
quit;
```

10. Create epi curve of weighted visits by month and year:

```
%let gpath='\\cdc.gov\private\L317\icj2\Studies\HFM';
%let dpi=200;

ods html close;
ods listing gpath=&gpath image_dpi=&dpi;

   /* Sort by onset date */
   proc sort data=hfm.hfm_neds_analysis out=dataset;
   by amonth hfm;
   run;

   /* Get onset date range and generate YearMonth variable */
   DATA HFM2;
   SET HFM.HFM_NEDS_ANALYSIS(KEEP= YEAR AMONTH HFM DISCWT) END=LAST;
   IF HFM=1 AND AMONTH NE . ;
   MIN=MIN(MIN, AMONTH);
   MAX=MAX(MAX, AMONTH);
   YEARMONTH= YEAR  || '-' || PUT(AMONTH, MONTHF.);
   IF LAST THEN DO;
         CALL SYMPUT ("MIN", MIN);
         CALL SYMPUT ("MAX", MAX);
   END;
   RUN;
   /* Get weighted visits my month and year */
   PROC SUMMARY DATA=HFM2;
   CLASS YEARMONTH;
   VAR HFM;
   WEIGHT DISCWT;
   OUTPUT OUT=OUTBREAK SUM=VISITS;
   RUN;

   DATA OUTBREAK;
   SET OUTBREAK;
```

```
IF _TYPE_ =  0 THEN DELETE;
LABEL YEARMONTH = 'MONTH AND YEAR OF VISIT' VISITS='WEIGHTED VISITS';
RUN;

GOPTIONS  RESET=ALL DEVICE=ACTXIMG;
ODS  HTML FILE="OUTBREAK.HTML";
TITLE 'HAND, FOOT, AND MOUTH DISEASE EMERGENCY DEPARTMENT VISITS* AMONG
CHILDREN AGE < 5 YEARS, UNITED STATES, 2006-2012';
PROC  GCHART DATA=OUTBREAK;
VBAR YEARMONTH /SUMVAR= VISITS DISCRETE;
RUN;
GOPTIONS  RESET=ALL DEVICE=ACTXIMG;

QUIT;
```

OUTPUT

The overall average rate of Hand, Foot, and Mouth Diseases related hospitalizations is shown in Table 1.

HOSPS	STANDARD ERROR	CENSUS TOTAL	HOSPS/100000	raterse1	LOWER 95% CI	UPPER 95% CI
189,815	6,808	140,881,459	134.7	4.83257	125.3	144.2

Table 1. Hand, Foot and Mouth Disease ED Visits, Children under 5 yrs, CATEGORY=HFM (All diagnoses), US, 2006-2012, NEDS, Average Rate

The rate of Hand, Foot, and Mouth Disease related hospitalizations by year is show in Table 2. Bi-annual peaks of HFMD are typical through 2010. However, in late 2011 through spring 2012, increased clusters of disease were noted by medical care providers and the uncharacteristic number of cases those years is reflected in NEDS, as seen in Table 2 and Figure 1.

Calendar year	HOSPS	STANDARD ERROR	CENSUS TOTAL	HOSPS/100000	raterse1	LOWER 95% CI	UPPER 95% CI
2006	20,773	1,549	19,938,883	104.2	7.7699	89.0	119.4
2007	12,320	1,087	20,125,962	61.2	5.4030	50.6	71.8
2008	22,201	1,698	20,271,127	109.5	8.3741	93.1	125.9
2009	16,095	910	20,244,518	79.5	4.4940	70.7	88.3
2010	19,620	1,256	20,189,075	97.2	6.2205	85.0	109.4
2011	25,967	1,730	20,122,198	129.0	8.5975	112.2	145.9
2012	72,839	5,873	19,989,696	364.4	29.3790	306.8	422.0

Table 2. Hand, Foot and Mouth Disease ED Visits, Children under 5 yrs, CATEGORY=HFM (All diagnoses), US, 2006-2012, NEDS, Rate by Year

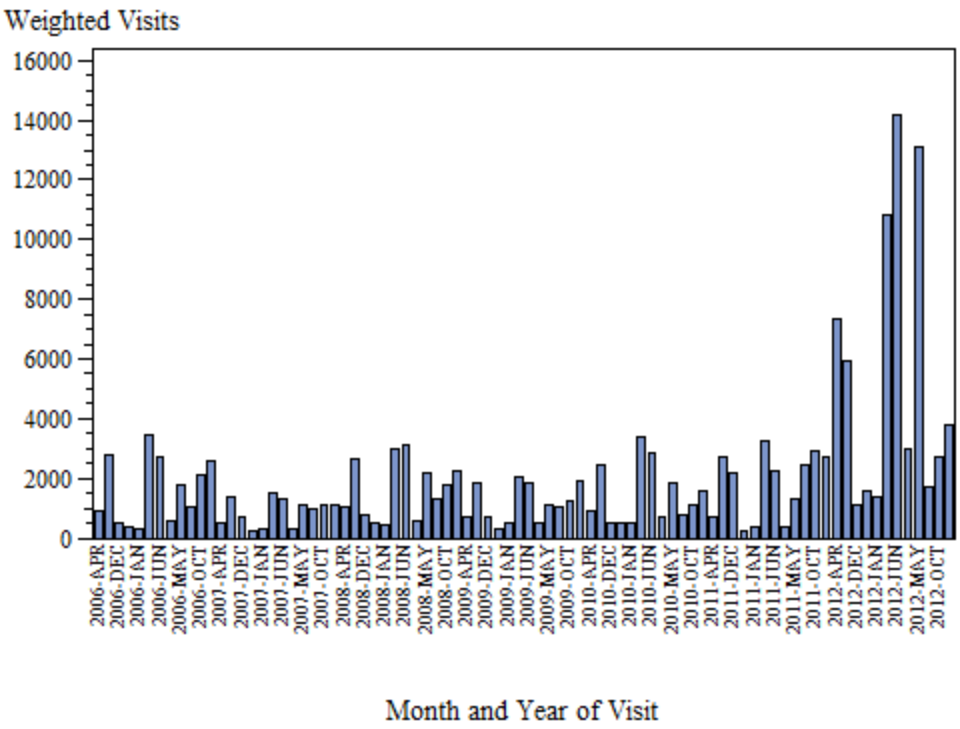

Figure 1. Hand, Foot, and Mouth Disease Emergency Department Visits* Among Children Age < 5 Years, United States, 2006-2012

CONCLUSION

While HFMD is a common childhood infection, hospitalizations associated with the disease are typically rare. Severe rash and hospitalizations have been associated with HFMD cases reported in the US during 2011-2012[5]. Without national reporting or surveillance systems for HFMD, it is difficult to know the impact of changes in circulating serotypes on rates of hospitalizations. This study provides baseline national estimates of HFMD-associated hospitalizations occurring among young children in the United States. The re-usable SAS code utilized in this project is a readily available resource for researchers to quickly produce estimates of burden of disease as new years of national data become available.

REFERENCES

CDC, National Center for Health Statistics, bridged race data file. (Available at: http://www.cdc.gov/nchs/nvss/bridged_race/data_documentation.htm) Last accessed 6/24/2016.

HCUP NEDS Database Documentation. Healthcare Cost and Utilization Project (HCUP). May 2016. Agency for Healthcare Research and Quality, Rockville, MD. (Available at: http://www.hcup-us.ahrq.gov/db/nation/neds/nedsdbdocumentation.jsp) Last accessed 08/24/2016.

RECOMMENDED READING

- *Cody, Ron. 2007. Learning SAS® by Example: A Programmer's Guide. Cary, N.C.: SAS Institute Inc*

CONTACT INFORMATION <HEADING 1>

Your comments and questions are valued and encouraged. Contact the author at:

Jessica M. Rudd, MPH

PhD Candidate, Analytics and Data Science
College of Science and Mathematics
Kennesaw State University
1000 Chastain Road
Kennesaw, GA 30144
Phone: 631.275.6698
Email: jrudd1@students.kennesaw.edu