SURVEILLANCE OF FOETAL ALCOHOL SYNDROME (FAS) USING SAS/FSP® AND SAS/AF® SOFTWARE WITH SCL

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ABSTRACT

About 8,000 babies are born each year with the characteristic birth defects or developmental disabilities associated with *in utero* exposure to maternal consumption of alcohol. These characteristics are collectively know as Foetal Alcohol Syndrome (FAS). The CDC uses an epidemiological approach to assist states to address public health problems. The first step to help South Dakota address the FAS problem was to develop and establish a surveillance system. SAS® software on the PC, featuring SAS/AF® and SAS/FSP® software, was used to construct a PC-based, menu-driven database management facility: Foetal Alcohol Syndrome Applications Facility (FASAF). FASAF is characterised by the capability for precise and accurate data entry using SAS Screen Control Language (SCL). FASAF, therefore, can be easily implemented in the field by nonSAS users for automated medical chart abstraction.

INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), about 4,000 babies are born each year with a defined set of abnormal physical characteristics or birth defects to mothers who have consumed inordinate quantities of alcohol while pregnant. Another 4,000 babies are born each year with a predisposition for cognitive and behavioural deficiency or developmental disabilites to similarly behaved mothers. These types of birth defects and developmental disabilities caused by *in utero* exposure of the baby to maternal consumption of alcohol are termed Foetal Alcohol Syndrome. Other not easily detectable effects of *in utero* exposure to alcohol are termed Foetal Alcohol Effects (FAE), or Alcohol Related Birth Defects (ARBD) and Alcohol Related Developmental Disabilities (ARDD).

In its epidemiologic approach to prevention of public health problems, the CDC assists states in setting up surveillance for these problems. Surveillance for FAS and FAE will allow the state to have a database on hand by which to be able to identify mothers at high risk to be delivered of an FAS/FAE baby, to be able to assist such mothers in reducing their risk, and to be able to provide assistance to those babies or children who are already characterized by FAS or FAE. That is, the state will have the ability to conduct case-prediction, early intervention and case management.

The task to provide surveillance assistance to the state of South Dakota has been borne out of an interagency collaborative effort between the CDC, the Indian Health Service, and the states of Alaska and South Dakota. The data entry facility described herein was to be used by clerical staff to enter data from hard copy medical record abstraction forms, and is a component of the Foetal Alcohol Syndrome Applications Facility (FASAF). FASAF is the outgrowth of two sources of data collection and an automation tool. Specifically, the South Dakota FAS Surveillance Project draws upon medical chart abstraction administered by the FAS Surveillance Coordinator, and the developmental clinic visits conducted by the FAS Surveillance Director, a physician. The automation tool selected was SAS software, version 6.04, for the PC, and the applications developer blends the capabilities of the software with the preferences of the Project Director and Coordinator. This is reflected in the third objective to reaching the goal of developing and establishing an FAS surveillance system, that is, to control for accurate and precise data entry, since clerical staff, with little to no scientific experience, would perform data entry.

Since the developmental clinic component is still under development, the acronym FASAF will be used without loss of interpretation, to represent the medical chart abstraction database management facility.

METHOD

SAS/AF software

SAS/AF software was used to construct a menuing system in order to preserve user-transparency in creating and accessing SAS data sets. FASAF is characterised by a main menu **DISPLAY** window for database management (Figure 1). A

```
Chart Abstraction Main Menu
Select Option ===>

                 SOUTH DAKOTA FAS SURVEILLANCE
         FASAF (VERSION 6)--CHART ABSTRACTION MAIN MENU

                         Data forms

   1. Medical chart abstraction--single-record data entry
   2. Medical chart abstraction--multiple-record browsing

   3. Growth chart--single-record data entry
   4. Growth chart--single-/multiple-record browsing

                      Other information

   5. Orientation

   6. Other activities (print select lists, counts, etc.)

   7. Quit--Press F10.
```

Figure 1. FASAF main menu

submenu **DISPLAY** window, branching from the main menu, allows the user access to a two-screen **DISPLAY** listing key notes or instructions. Also accessible through the submenu is a credit or acknowledgement screen **DISPLAY** identifying the participants associated with the interagency collaborative effort for South Dakota FAS Surveillance. For this application, these screen **DISPLAY** types were stored as **HELP** entries in a single FASAF catalog (Figure 2). All menu and submenu

```
BUILD: ATTR ABSFRM.MENU (E)
Command ===>

 Option    Name      Type      libref    Catalog    Menu-Link

 1         ABSFRMDE  PROGRAM   *         *          _
 2         ABSFRMB   PROGRAM   *         *          _
 3         GCHRTDE   PROGRAM   *         *          _
 4         GCHRTB    PROGRAM   *         *          _
 5         ORIENT    MENU      *         *          _
 6         OTHER     MENU      *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
 ........  ........  ........  *         *          _
                                                   ZOOM
```

Figure 2. ATTR window for main menu

DISPLAY windows were stored as **MENU** entries in the same FASAF catalog.

To assist the user in understanding any extended features of the current menu selection, or in order to ensure that data entry personnel are certain about their selected main menu option, "confirmation" **DISPLAY** windows open following one of four menu selections, whereby the database may be added to, editted, or simply browsed (Figure 3). In these windows,

```
 4. Growth chart--browse
Command ===>
To exit quickly, press F10.
                    SOUTH DAKOTA FAS SURVEILLANCE
          FASAF (VERSION 6)--GROWTH CHART BROWSE CONFIRMATION

 This option opens the Growth Chart data set in browse mode.
 You may browse the data set
   (i) one record at a time using the data entry screen, or
  (ii) in tabular form headed with the SAS variable names.

 Note:  No records may be added.  No records may be editted.

 Press TAB or SHF TAB to select browse option.  Make one selection.

 Do you wish to browse individual records per screen? _ (Y=Yes)

 Do you wish to browse multiple records per screen? _ (Y=Yes)

 If not, press F10 to return to the main menu.
```

Figure 3. Data browsing confirmation--growth chart

the specific features of the selected main menu option are displayed and describes more fully the particular selection and restrictions which could possibly be encountered. The user then has to choose between proceeding with this main menu selection, or returning to the main menu. Transparent to the user, if the user chooses to proceed, is the SCL code written in the **SOURCE** window which invokes SAS/FSP software using the **CALL** statement. Each **DISPLAY** window and its associated **SOURCE** window were stored in the FASAF catalog as a **PROGRAM** entry.

Preserving security for this database was a concern of the FAS Surveillance Project staff. SAS/AF was used to front FASAF with a security window. In this window, FASAF is clearly identified as U.S. Government property and without proper clearance, the user cannot access the database. Various warnings are issued upon repeated attempts to by-pass this window. This security feature comprises a **DISPLAY** window and a **SOURCE** window, and is stored in the FASAF catalog as a **PROGRAM** entry.

SAS/FSP software

SAS/FSP software is implemented for data entry or browsing of data sets. The user selects an option from the main menu and responds affirmatively in the confirmation window. Transparent to the user, SCL code executes and the user gains access to the database.

To facilitate data entry, a series of customized screens are displayed in order to effect uninterrupted keying of an abstraction form. Specifically, data entry proceeds one record at a time into a relational database consisting of two SAS data sets. The medical chart data set comprises 359 labelled and formatted variables, accessed through 17 data entry screens. The "accessory" growth chart data set includes 17 labelled and formatted variables displayed on one data entry screen and contains multiple records per individual corresponding to a single record per abstraction form keyed into the medical chart data set. Opening the data entry facility for the growth chart can occur either directly from the main menu, or from the appropriate screen during data entry of the medical chart abstracted data using a **CALL FSEDIT** statement in the **SCL** (Figures 1 and 4). Prior to keying data

```
FSEDIT SD.ABSTFORM
Command ===>                                                   Obs    0
WARNING: No observations on data set. Please press END or ADD.   Screen 10
                              ICD-9 search code: _____   Entry #: ___
SECTION 3:  FAS DIAGNOSTICS--GROWTH DEFICIENCY

 Is growth deficiency mentioned in the chart: _ (Y=Yes, N=No)

 Was failure-to-thrive (FTT) diagnosed:       _ (Y=Yes, N=No)

 Was growth deficiency calculated:            _ (Y=Yes, N=No)

 Do you wish to enter growth chart data now?  _ (Y=Yes, then press ENTER.)
                                                (If "No", then leave blank.)
 Otherwise, ...

To access the growth chart data independent of the chart abstraction form,
return to the main menu (press F10) then select option 3.

Press F10 from any screen.  All data entries or changes will be saved.
This current menu selection will be terminated.  You will return to the main
menu.

[Screens 1-9: SHF F7; Screens 11-17: SHF F8]
```

Figure 4. Medical chart data entry, Screen 10

from an abstraction form and in order to facilitate data entry, an identification or entry number is assigned to that form and keyed into the first data entry screen of that record. SCL is used to pass and display that number onto all following screens where this repeated field is protected from editting. This feature was set up in the **PROTECT** frame of the **FSEDIT** Attribute window. The entry number is also passed to the growth chart data set using the **CALL SYMPUT** and **SYMGET** macro variable assignment and retrieval functions in the respective **PROGRAM** catalog entries. This is done in order to reduce the chance of the user incorrectly keying the entry number when growth chart data are to be enterred. The user can interrupt data entry and safely return to the point of interruption and, therefore, to the correct abstraction form being keyed. In addition, there are computed fields in the data entry facility which exempt the user from performing certain calculations or from keying summary information derived from examining the data already keyed or collected on the abstraction form. These features are hinted to the user by an on-screen expression: ["ENTER"-->] (Figures 5 and 6).

```
FSEDIT SD.ABSTFORM
Command ===>                                                    Obs     0
WARNING: No observations on data set.  Please press END or ADD.  Screen  3
                                 ICD-9 search code: _____   Entry #: ___
SECTION 1:  PATIENT INFORMATION (2nd of 2 screens)

 Gestational age          __ weeks

 Birth weight       (gm) ___   or  (lb) _ (oz) _   ["ENTER" -->] IUGR: __
 Length             (cm) ___   or  (in) ____
 Head circumference (cm) ___   or  (in) ____

 Address at time of birth:          Date address recorded: _________
  Street ______________________________________________
  City ________________  County ________________
  State _  Zip code ____

      Other birth defects       ICD code
 ___________________________     _____
 ___________________________     _____
 ___________________________     _____
 ___________________________     _____
 ___________________________     _____
[Screens 1-2: SHF F7; Screens 4-17: SHF F8]
```

Figure 5. Medical chart data entry, Screen 3

Although the user may browse any of the data sets using the data entry selections from the main menu, during browsing as specifically selected from the main menu, the user is barred from any editting of the data. The main feature of these browse selections are to be able to display the data either one record at a time in data-entry layout as invoked by the **FSEDIT** routine in **BROWSE** mode, or to display the data in tabular form for a multirecord comparative display as invoked by the **FSPRINT** routine.

SAS Screen Control Language

SAS Screen Control Language (SCL) was developed, is transparent to the user, and executes for confirmation of main menu selection options and for quality control during data entry.

Once the user confirms his/her main menu selection via the confirmation window, the SCL **SOURCE** program executes and a **CALL** statement invokes the **FSEDIT** routine, the **FSEDIT** routine in **BROWSE** mode, or the **FSPRINT** routine,

```
FSEDIT SD.ABSTFORM
Command ===>                                                    Obs     0
WARNING: No observations on data set.  Please press END or ADD.  Screen 13
                                 ICD-9 search code: _____   Entry #: ___
SECTION 5:  PREVIOUS MENTIONS OF FAS/FAE/ARBD/ARDD
                                               +----------------------+
     Date          Diagnostician     Diagnosis | 1 = FAS     2 = FAE  |
  __________     ________________        _     | 3 = FAS/FAE          |
  __________     ________________        _     | 4 = Suspect (S)/     |
  __________     ________________        _     |     Probable (P)/    |
  __________     ________________        _     |     Possible (P)/    |
  __________     ________________        _     |     Rule out (R) FAS |
  __________     ________________        _     | 5 = S/P/P/R FAE      |
  __________     ________________        _     | 6 = No FAS/FAE       |
  __________     ________________        _     | 7 = Alcohol exposure |
  __________     ________________        _     |     in utero         |
  __________     ________________        _     | 8 = ARBD    9 = ARDD |
                                               +----------------------+
 ["ENTER"-->]          FAS/  S/P/P/R  S/P/P/R-  No   Alc. exp.
                 FAS  FAE  FAE    FAS      FAE   FAS/  in utero  ARBD  ARDD
Frequency of
 mention         _    _    _      _        _     _       _        _     _

[Screens 1-12: SHF F7; Screens 14-17: SHF F8]
```

Figure 6. Medical chart data entry, Screen 13

where the latter two routines allow noneditable browsing of data, and the first routine allows data to be enterred and data sets to be editted (Figure 7). This SCL code is also used to issue warning/informational messages, for example, how to quickly terminate the current session.

```
main:

 if gcbs = 'Y' & gcbm = 'Y' then do;
   alarm; cursor gcbs;
   _msg_ = 'Make one selection only.';
 end;

 if (gcbs = 'Y' & gcbm ne 'Y') |
    (gcbs ne 'Y' & gcbm = 'Y') then do;

   call putlegend (1, ... ,'p');
   call putlegend (2, ... ,'c','r');
   call putlegend (3, ... ,'c','r');
   call putlegend (4, ... ,'c','r');
   call legend ('Growth Chart browsing--');

   if gcbs = 'Y' then do;
    call fsedit('lr.gc','lr.fascat.gcscr','browse');
   end;

   if gcbm = 'Y' then do;
    call fsprint ('lr.gc');
   end;

   call endlegend();
  end;

return;
```

Figure 7. SCL--browsing growth chart data

Quality control of data entry was designed to allow for nonscientific staff to key data. The three types of data checking include (i) 93 validation checks which ensure that the correct values are keyed, (ii) 12 consistency checks which ensure that logical entries are made among associated fields, and (iii) 20 range checks which ensure that outliers are not accidentally created by incorrect keying. SCL was developed to perform the first two of these data entry quality control checks. Validation and consistency checks used the **ARRAY** and **IF** statements. SCL was used to sound an alarm when a check failed, locate the cursor at the source of the error, and display a warning message using the **ALARM**, **CURSOR**, and **_MSG_** statements (Figure 8). Range checks, including maxima and minima constraints, did not require SCL syntax, but were set up in the **MAXIMUM** and **MINIMUM** frames of the **FSEDIT** Attribute window. Another aspect of data entry quality control was the allowance of error override in certain cases. By design, this was contingent on supervisory approval since an error or warning message was always issued upon accessing a record which failed at least one SCL syntax check. Error override was implemented via the **FSEDIT** Parms or parameter definitions window.

```
  main:
   .
   link compute;
   .
  return;
   .
   .
  compute:

/* --Validate previous mentions of FAS/FAE-- */
    array pmdxnum {10} pmdx1-pmdx10;
    do i = 1 to 10;
      if pmdxnum{i} ne . &
        pmdxnum{i} lt 1 | pmdxnum{i} gt 9 then do;
       alarm;
       _msg_ = 'Improper entry! Use codes on screen';
      end;
    end;
/* --Produce on-screen distribution of previous
mentions of FAS/FAE-- */
    array cntarr {9} cnt1-cnt9;
    diffdx = 0;
    do j = 1 to 9;
      cntarr{j} = .;
      do k = 1 to 10;
       if pmdxnum{k} = j then cntarr{j} + 1;
      end;

/* --Produce 1 response on Screen 17 from Screen
13-- */
      if cntarr{j} gt 0 then diffdx + 1;
    end;
    if diffdx gt 1 then multdx = 'Y';
    else multdx = 'N';
/* --Produce 1 response on Screen 17 from Screen 5-- */
    if etoh0 = 'Y' then alcdx = 'Y';
    else alcdx = 'N';

/* --Compute IUGR given sex and gestational age and
birthweight-- */
/*
"Intrauterine growth as estimated from liveborn birth-weight
data at 24 to 42 weeks of gestation", Lula O. Lubchenco,
M.D., Charlotte Hansman, M.D., Marion Dressler, M.D., and
Edith Boyd, M.D. Pediatrics, November 1963. Pp. 793-800.
*/
  if sex = 'M' & ga ne . & bwtgm ne . then do;
   if ga = 24 & bwtgm lt 610 |
     .
     .
     ga = 42 & bwtgm lt 2780 then iugr = 'SGA';
   else if ga = 24 & bwtgm gt 1230 |
       .
       .
       ga = 42 & bwtgm gt 3995 then iugr = 'LGA';
   else iugr = 'AGA';
  end;
  if sex = 'F' & ga ne . & bwtgm ne . then do;
   if ga = 24 & bwtgm lt 490 |
     .
     .
     ga = 42 & bwtgm lt 2690 then iugr = 'SGA';
   else if ga = 24 & bwtgm gt 1250 |
       .
       .
       ga = 42 & bwtgm gt 3840 then iugr = 'LGA';
   else iugr = 'AGA';
  end;

 return;
```

Figure 8. SCL--medical chart data entry

Other applications of SCL syntax during data entry were to open **DISPLAY** windows of **HELP** catalog entries at various points in the data entry facility. SCL was used to evaluate the entry of certain fields, and if incorrect or illogical entries had been keyed, a **CALL DISPLAY** statement would execute and these "pop up" help windows would open so as not to obscure the field in question. For other invalid entries, SCL was used to issue warnings and to draw the user's attention to an onscreen window displaying valid data entry values. SCL was also used for the computation and display of summary or sequential data fields mentioned above.

Finally, an informative and fully illustrated documentation/ coding manual was prepared to be primarily a technical reference guide and also a user's manual insofar as onscreen information and instruction was incomplete. This manual, therefore, documented procedural requirements and anomalies and discussed the unique features of each screen. Prefacing the documentation was a one-page, quick-reference user's guide on how to implement FASAF. Appended to the documentation were the specifics on data entry quality control, illustrations of the "pop up" help windows, lists of variables and attributes of the database produced by **PROC CONTENTS**, and the SCL associated with confirmation windows and data entry.

RESULTS

The advantages of applying SAS/AF and SAS/FSP software to database management lies in the ability to custom design the facility to suit the end-user. In this case, considering the environment under which FAS surveillance is to take place and the data storage facilities, an application facility, FASAF, was able to be constructed with a security "front-end" immediately upon invoking SAS on the user's PC. The current disadvantage of this artful feature is that authorized data managers cannot readily access the database. Considering the expertise of the data entry personnel, SAS/AF and SCL were combined to produce a user-friendly instrument with data entry controls for the nonSAS, nonscientific data entry personnel. However, for scientific staff, the obverse of smooth may prove to be sticky. Also, FASAF was developed on a Compaq 486 PC in Atlanta, Georgia and implemented on a Compaq 386 PC in Rapid City, South Dakota, whereby the contrasting demands between these two PCs, reflecting the limitation of resources, have become evident.

CONCLUSION

In an effort to assist the state of South Dakota with addressing FAS, the CDC offered software support to develop and establish a surveillance system. Contracting through Battelle, SAS software was selected because of the attributes of SAS/AF and SAS/FSP software. The product presented to the South Dakota FAS Surveillance Project was a PC-based, menu-driven, multiscreen data entry facility known as FASAF which was designed to allow nonSAS users to easily implement FASAF. Implementation of FASAF results in the construction of a relational database. Using SAS SCL, quality control checks were built into FASAF allowing for the capability of implementing the facility in the field for a fully automated, precise and accurate data entry system. The features of SAS/AF and SCL contributed to the application opening with a security window thus disallowing unauthorized access to the system.

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