Web-Based Integration of Data Collection and Reporting Based on SAS Foundation Technologies

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ABSTRACT

The variety of database, statistical analysis, and reporting software products available to today's organizations makes it increasingly difficult to identify the best combination of products that fits the needs of a project. Many factors have to be considered when making this choice such as product features, product support, support staff, timeline, long term planning, ease of use, and product stability.

Faced with the challenges of supporting a legacy web-based data collection application that utilized Java, JavaScript, and Oracle, and an increasing demand for rapid generation of reports and data sets, the Northern California Kaiser Permanente's Division of Research (DOR) decided to move its regional registry of neonatal intensive care patient outcomes to a SAS-driven web-based application. This presentation summarizes how the SAS system was used to create a web-based application called the Neonatal Minimum Data Set (NMDS) to provide a one-stop solution for a) data collection; b) data reporting; c) analytic data base generation; d) advanced reporting including sophisticated analytical methods; and e) monitoring of specific QI goals by clinical staff across the Northern California region.

(174 words)

INTRODUCTION

The Kaiser Permanente Neonatal Minimum Data Set (NMDS) is in its fifth version (NMDS-V) of on-line data collection from Kaiser Permanente's Neonatal Intensive Care Units (NICU) permitting rapid retrieval of neonatal and perinatal care statistics. From its inception, NMDS has created a high quality data repository that establishes relationships between demographic, diagnostic, and physiologic factors with associative outcomes of in-hospital-deaths, duration of stays, major invasive procedures, and major morbidity data to conduct complex statistical outcome and research analyses. Additionally, the NMDS has served as a "go-to" resource for various internal and external reporting requirements.

Before launching NMDS-V with the SAS system, NMDS evolved from MS Access to SQL to Oracle. Although the NMDS using Oracle satisfied the continual need to collect data and provide a data repository for research, the maintenance and ease of enhancements were challenging. Specifically, the system required a single staff member to understand an array of tools such as, HTML, JSP, JDBC, Oracle (tables, triggers, stored procedures), and SAS. Therefore, adding a new variable required a significant amount of expertise and time. Additionally, for ease of use for all staff, the Oracle tables were periodically converted to SAS, and the application did not provide any on-line static or dynamic reports.

Since the DOR utilizes SAS for its primary statistical and data management tool, it was evident that NMDS-V use SAS technologies. The following paper provides an overview of SAS Foundation Technology methods, specifically Base SAS, SAS/Graph, and SAS/IntrNet, used not only to collect and maintain a rich research database but to enhance NMDS with advanced reporting and QI monitoring.

NMDS-V APPLICATION GOALS

Based on experience with the previous data collection mechanisms, the following goals were set for NMDS-V:

- Web-based;
- User-friendly environment for data abstractors with relevant help screens and an intuitive user environment;
- SAS data sets;
- Production application ready in fewer than 6 months;
- Data integrity: features that check for data consistency, issue error alerts, record completeness;
- Integrated user management of at least 5 different user types (administrator, abstractor, transport system specialist, reviewer, report generator) with different levels of database and system access; ability to handle up to 20 concurrent users;
- Integrated support of database generation to meet needs of multiple constituents: national and statewide patient outcome registries, payer-sponsored quality benchmarking programs, and regional and local QI initiatives by KP clinical staff;
- Integrated reporting on user, database, and analytic activity;
- SAS programming for adding, deleting, maintaining databases, and all reporting features;
- Ability to archive older data, perform backups, track data edits;
- Integration of legacy data collected for prior years.

NMDS-V APPLICATION OVERVIEW

The NMDS-V application requires knowledge of HTML, JavaScript, Cascading Style Sheets, and SAS, particularly SAS/Macro language.

HTML is used to interact with the user. JavaScript is used to implement dynamic form features such as error checking and issuing user alerts if implausible data points are entered. Data is collected on web forms and then submitted to SAS using SAS/IntrNet. All data sets are stored as SAS data sets.

The application server service is set up as a Socket service working on one request at a time in the order in which the requests are made. This setup was sensible since the total number of concurrent users is small and each type of request is handled in fractions of a second. Figure 1 displays the control flow in NMDS-V. The user initiates a request from a client on the KP intranet through the NMDS web server. The web server sends the request to the application server. The application server processes the request and sends the result of the request back to the web server. The web server handles the display of the result to the client.

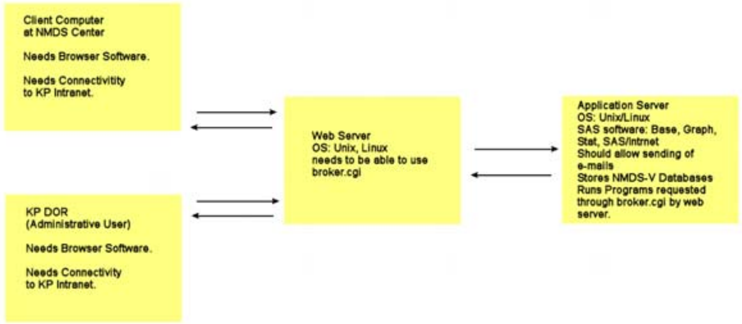


Figure 1: Control Flow in NMDS-V

Files maintained on the web server include all JavaScript needed to perform error checking, a set of HTML documents providing context-sensitive help when requested by the user, and a set of cascading style sheets. The application server handles all processing and generates a result in HTML to display back to the user.

LOGON PROCESS AS AN EXAMPLE

This section explains the logon script as a simple example of the control flow in NMDS-V. Figure 2 shows the logon screen.

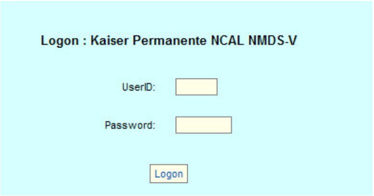


Figure 2: NMDS-V Logon Screen

The logon screen consists of a form requesting a user id and password. The relevant part of the HTML form is shown below.

```
<h2>Logon : Kaiser Permanente NCAL NMDS-V </h2>
<form method="POST" action="/cgi-bin/broker.cgi" autocomplete="off">
<input type="hidden" name="_program" value="progs.nmds.sas">
<input type="hidden" name="ToDo" value="logon">
<input type="hidden" name="_service" value="nmds">
<input type="hidden" name="_debug" value="0">
<table>
<tr><td style="text-align:right;padding-top:20px;padding-right:20px;">UserID:</td>
    <td style="text-align:left;padding-top:20px;">
    <input name="userid" type="text" size="3" maxlength="3"
           onchange="javascript:upCap(this.form,'userid');" /></td>
</tr>
<tr><td style="text-align:right;padding-top:20px;padding-right:20px;">Password:</td>
    <td style="text-align:left;padding-top:20px;">
    <input name="password" type="password" size="6" maxlength="8" /></td>
</tr>
<tr><td colspan="2" style="text-align:center;padding-top:30px;">
    <input class="btn" onmouseover="this.className='btn btnhov'"
           onmouseout="this.className='btn'" type="submit" value="Logon" /></td>
</tr>
```

```
   </table>
   </form>
```

All elements of the form that are sent to the application server upon submission are highlighted. Note the use of the action parameter of the form `/cgi-bin/broker.cgi` that instructs the web server to find what action to take by looking at the broker.cgi script. Also note the parameters that are needed to send this request to the correct “place.” These parameters are hidden to the user. The parameter `_service` processes the request to the correct application server. The parameter `_program` identifies the SAS program that is run on the application server in response to the request; in this case the program nmds.sas is called which has to be present in the program library `progs` that must be defined on the application server. The parameter `ToDo` is also sent with this request. It is needed for the program `nmds.sas` to run correctly.

Once this form is successfully processed by the web server and sent as a request to the application server, the application server will process it by running the SAS code in `nmds.sas` shown below:

```
   %MACRO initialize;
   %GLOBAL commonwwwroot nmdsroot extHTMLpath wzpath logfilefolder sysslash faclist
           KPlist NMDSlist edsfiles;
   %LET faclist=[…];
   %LET KPlist=[…];
   %LET NMDSlist='HAY' 'OAK' 'WCR' 'SCH' 'SFO' 'SAC';
   %IF &sysscp EQ WIN %THEN %DO;
       %LET commonwwwroot=/nmds/;
       %LET nmdsprgs=c:\projects\Kaiser DOR;
       %LET nmdsroot=c:\projects\Kaiser DOR;
       %LET extHTMLpath=&nmdsprgs\externalHTML;
       %LET logfilefolder=c:\SASInt~1\nmds\logs;
       %LET wzpath=c:\progra~1\utilit~1\winrar;
       %LET sysslash=%STR(\);
       OPTIONS MAUTOSOURCE SASAUTOS=("&nmdsprgs\maclib",sasautos);
       %LET edsfiles=c:\projects\Kaiser~1\cpqcc\edsfiles;
       OPTIONS NOXWAIT; /* not a unix option! */
   %END;
   %ELSE %DO;
       %LET commonwwwroot=/;
       %LET nmdsroot=/home/xxx/nmds5-app;
       %LET nmdsprgs=/home/xxx/nmds5-app;
       %LET extHTMLpath=&nmdsroot/externalHTML;
       %LET logfilefolder=/home/xxx/intrnet/nmds5/logs;
       %LET sysslash=%STR(/);
       OPTIONS MAUTOSOURCE SASAUTOS=("&nmdsprgs/maclib",sasautos);
       %LET edsfiles=&nmdsroot/cpqcc/edsfiles;
   %END;
   %MEND initialize;
   %initialize;
   %LET nmdsFromEmail=nmdssupport@nsmtp.kp.org;
   %setOptions;
   %LET errorcode=0;
   %LET maxstays=24;
%gonmds;
```

The program `nmds.sas` also performs several initialization tasks. As many of the SAS modules used by NMDS-V were developed in a windows environment, several global variables that are needed by the application are defined system specific.

After the initialization step is complete, yet another SAS macro is called, `%gonmds`. In fact each request that comes from the web server is routed to this “**gatekeeper**” macro. Depending upon the `ToDo` parameter sent with the web form, the macro `%gonmds` routes the request to the correct SAS program:

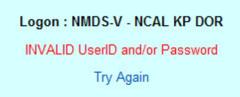
```
   […]
   %IF &ToDo EQ logon %THEN %DO;
       %logonkaiser;
   %END;
   […]
```

For the logon request the macro logonkaiser is called. This macro finally checks the supplied userid and password against a password protected database with allowed users.

```
   %MACRO logonKaiser;
   %GLOBAL userid password keycode browser usertype sysslash;
   DATA check;
        SET kaiser.users (READ=xxxxxx WHERE=(userid="&userid" AND pw="&Password"));
```

```
RUN;
%LET valid=%numobs(check);
%IF &valid=0 %THEN
  %DO; /*invalid logon*/
    %LET keycode=FAILED;
    DATA _NULL_;
      INFILE "&extHTMLpath&sysslash.invalidlogon.html" TRUNCOVER;
      FILE _webout;
      INPUT infile $32755.;
      INFILE = RESOLVE(infile);
      PUT infile;
    RUN;
  %END;
%ELSE
  %DO; /*valid logon*/
    %LET rc=%SYSFUNC(APPSRV_SESSION(CREATE, 3600));
    DATA _NULL_;
         SET kaiser.users (READ=xxxxxx
                             WHERE=(userid="&userid" AND pw="&Password"));
         CALL SYMPUT('keycode',keycode);
         CALL SYMPUT('usertype',usertype);
    RUN;
    %displayMessage;
  %END;
%MEND logonKaiser;
```

If the user is not found or if the password is incorrect, the program copies an `invalidlogon.html` file that resides on the application server to the `_webout` destination (see Figure 3).



Logon : NMDS-V - NCAL KP DOR

INVALID UserID and/or Password

Figure 3: NMDS-V Failed Logon

If the logon credentials are authenticated, the user can start using the application.

NMDS-V FEATURES SUMMARY

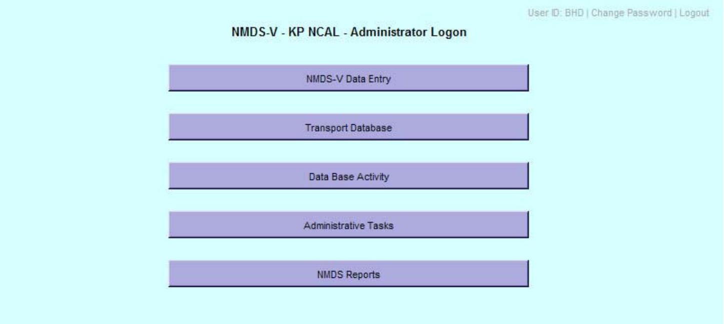
Describing each of the NMDS-V features in detail is beyond the scope of this presentation, therefore this section briefly outlines each function and how it was implemented.

SAS DATA SETS

Since SAS is the primary analytic tools used by the DOR, selecting SAS data sets for all NMDS-V data files was a logical choice.

USER-SPECIFIC FEATURES

The logon process not only authenticates the user, but also associates a user-type with each user. The set of NMDS-V features or modules that appears after the logon process is specific to each user-type..



NMDS-V - KP NCAL - Administrator Logon

Figure 4: NMDS-V Administrator Access

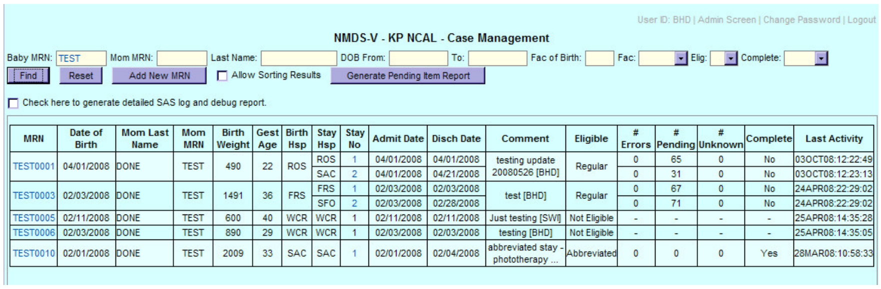
For instance, the user-type of data abstractor will be immediately placed in the data entry environment. A report user will be placed in the environment for report generation. A review only user may access all data and reports, but may not modify any data. Upon logon, the administrator user-type is presented with the choices shown in Figure 4.

The administrator has access to all data entry functions, data base activity reports, specific administrator only tasks, and all real-time reports. The administrator-only tasks include user management functions such as addition and removal of NMDS-V users, updating information, resetting the password for NMDS-V users, and other functions.

In the top right section of each NMDS screen, the user id along with additional navigational choices for the current screen is provided.

DATABASE ACCESS

The main case management screen that handles access to the NMDS-V data bases is shown in Figure 5. When the screen is initially loaded, the bottom panel is empty. The user can specify any of the criteria listed at the top to retrieve a list of infant records meeting the selected criteria. In the example in Figure 5, the only criterion entered was the MRN. All infants are displayed in the list whose MRN starts with the four characters TEST.


User ID: BHD | Admin Screen | Change Password | Logout

NMDS-V - KP NCAL - Case Management

Baby MRN: TEST Mom MRN: Last Name: DOB From: To: Fac of Birth: Fac: Elig: Complete:

Find
Reset
Add New MRN
☐ Allow Sorting Results
Generate Pending Item Report

☐ Check here to generate detailed SAS log and debug report.

MRN	Date of Birth	Mom Last Name	Mom MRN	Birth Weight	Gest Age	Birth Hsp	Stay Hsp	Stay No	Admit Date	Disch Date	Comment	Eligible	# Errors	# Pending	# Unknown	Complete	Last Activity
TEST0001	04/01/2008	DONE	TEST	490	22	ROS	ROS	1	04/01/2008	04/01/2008	testing update 20080526 [BHD]	Regular	0	65	0	No	03OCT08:12:22:49
							SAC	2	04/01/2008	04/21/2008			0	31	0	No	03OCT08:12:23:13
TEST0003	02/03/2008	DONE	TEST	1491	36	FRS	FRS	1	02/03/2008	02/03/2008	test [BHD]	Regular	0	67	0	No	24APR08:22:29:02
							SFO	2	02/03/2008	02/28/2008			0	71	0	No	24APR08:22:29:02
TEST0005	02/11/2008	DONE	TEST	600	40	WCR	WCR	1	02/11/2008	02/11/2008	Just testing [SWI]	Not Eligible	-	-	-	-	25APR08:14:35:28
TEST0006	02/03/2008	DONE	TEST	890	29	WCR	WCR	1	02/03/2008	02/03/2008	testing [BHD]	Not Eligible	-	-	-	-	25APR08:14:35:05
TEST0010	02/01/2008	DONE	TEST	2009	33	SAC	SAC	1	02/01/2008	02/04/2008	abbreviated stay - phototherapy ...	Abbreviated	0	0	0	Yes	28MAR08:10:58:33

Figure 5: NMDS-V Case Management

Depending upon the user type a debug feature is available to the user. While such debug features are usually not recommended for SAS/IntrNet driven dynamic websites, the addition of this feature for specific users was deemed acceptable since NMDS-V is only accessible via the Kaiser DOR Intranet. As the use of SAS/IntrNet was new to some Kaiser DOR staff involved in this project, use of the debug feature allows a high level SAS user to better understand program flows when familiarizing themselves with the details of the NMDS-V system design.

To handle all the different actions that can be triggered by the screen shown above, several HTML forms are used. For instance, along with the visible form components, the hidden form components below are associated with the user performing a search:

```
<input type="hidden" name="ToDo" value="selectCases" />
<input type="hidden" name="casesPresent" value="N" />
<input type="hidden" name="_program" value="progs.nmds.sas" />
<input type="hidden" name="_service" value="nmds" />
<input type="hidden" name="_sessionid" value="b21iTnyDL52" />
<input type="hidden" name="_server" value="nmdsserver" />
<input type="hidden" name="_port" value="51028" />
<input type="hidden" name="userid" value="XYZ" />
<input type="hidden" name="_debug" value="0" />
```

Depending upon the user type associated with the `userid`, the gatekeeper program `gonmds.sas` (see page 3) routes the request to the execution of the correct set of SAS macros.

```
[…]
%ELSE %IF &ToDo EQ selectCases %THEN %DO;
      %IF &usertype EQ ro %THEN %DO;
          […]
          %selectCases;
      %END;
      %ELSE %DO;
          […]
          %checkIC;
          %selectCases;
      %END;
%END;
[…]
```

The list generated has several hot links that allows access to additional screens needed to manage the information abstracted for the NICU patients.

The case management screen was designed to explicitly address the needs of the NMDS-V application based on experience with previous data entry applications and tasks that need to be performed repeatedly and efficiently. For instance, after the application was in use for several months, users asked for the ability to easily generate a list of infants along with the list of items not yet abstracted. The flexibility of the chosen environment allowed this implementation with ease.

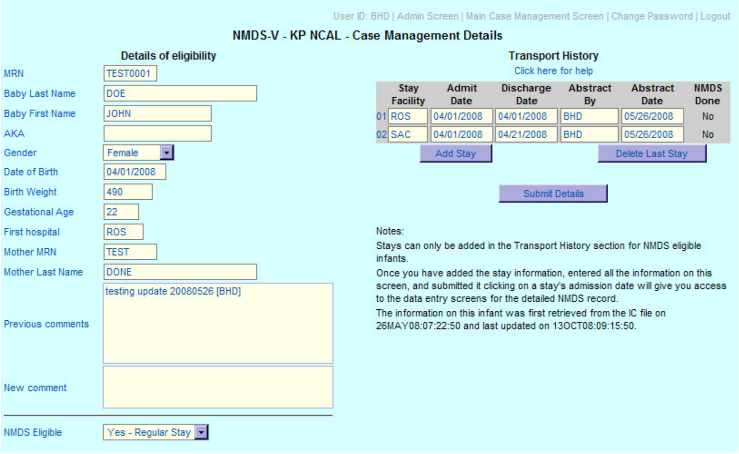
DATA ENTRY – PHASE I

Data entry occurs in two phases. In the first phase, eligibility of each NICU infant is ascertained and information from all stays at a Kaiser facility along with basic demographic information is captured. Eligibility screening of all infants born at a Kaiser facility or transferred to a Kaiser NICU occurs primarily through a case finding program that queries the KP admission/discharge databases pertaining to a maternal and newborn record. This process is complemented by the inspection of delivery room and NICU logs.

Clicking on any of the MRN hyperlinks in the result table in Figure 5 triggers the submission of an associated form and generates the screen shown in Figure 6 through the gatekeeper program `gonmds.sas` (see page 3):

```
[…]
%IF &ToDo EQ getDetails %THEN %DO;
%IF %STR(&mrnI) EQ NEWMRN %THEN %LET waitmsg=%STR(Loading Case Detail Screen);
%ELSE %LET waitmsg=%STR(Retrieving Details for Infant);
%getCaseDetails(history=Y);
%END;
[…]
```

Information present on the requested case is pulled from the NMDS-V databases and used to populate the form.


User ID: BHD | Admin Screen | Main Case Management Screen | Change Password | Logout
Click here for help
Add Stay
Delete Last Stay
Submit Details

NMDS-V - KP NCAL - Case Management Details

Details of eligibility

MRN	TEST0001
Baby Last Name	DOE
Baby First Name	JOHN
AKA	
Gender	Female
Date of Birth	04/01/2008
Birth Weight	490
Gestational Age	22
First hospital	ROS
Mother MRN	TEST
Mother Last Name	DONE
Previous comments	testing update 20080526 [BHD]
New comment	
NMDS Eligible	Yes - Regular Stay

Transport History

	Stay Facility	Admit Date	Discharge Date	Abstract By	Abstract Date	NMDS Done
01	ROS	04/01/2008	04/01/2008	BHD	05/26/2008	No
02	SAC	04/01/2008	04/21/2008	BHD	05/26/2008	No

Notes:

Stays can only be added in the Transport History section for NMDS eligible infants.

Once you have added the stay information, entered all the information on this screen, and submitted it clicking on a stay's admission date will give you access to the data entry screens for the detailed NMDS record.

The information on this infant was first retrieved from the IC file on 26MAY08:07:22:50 and last updated on 13OCT08:09:15:50.

Figure 6: NMDS-V Case Detail Management

Key components of one the SAS macros called are shown below.

```
%MACRO getCaseDetails(history=N);
%GLOBAL mrn commonwwwroot maxstays _debug browser sysslash faclist KPlist NMDSlist
usertype;
[…]
FILENAME out CATALOG "&_tmpcat..caseDetail.html";
/* header information */
DATA _null_;
     INFILE "&extHTMLpath&sysslash.nmdstop.html" truncover LRECL=2000;
     FILE out LRECL=2000;
     INPUT infile $2000.;
     infile = RESOLVE(infile);
     PUT infile;
RUN;
 /* additional header information specific for getCaseDetails */
DATA _null_;
     INFILE "&extHTMLpath&sysslash.%LOWCASE(getCaseDetailsHead).html" truncover
            LRECL=2000;
     FILE out LRECL=2000 MOD;
     INPUT infile $2000.;
     infile = RESOLVE(infile);
     PUT infile;
RUN;
[…]
DATA sub;
     LENGTH facVis1-facVis12 $ 3;
     SET nmds.allInfants (WHERE=(COMPRESS(mrno) EQ "&mrnI" AND _recent EQ 'Y'));
     CALL SYMPUT('updsrc',_updSrc);
RUN;
[…]
/* define populateForm function to populate the form with the information for the
   selected MRN */
%IF %EVAL(%numobs(sub) > 0) %THEN %DO;
DATA _null_;
     SET sub;
     FILE out LRECL=2000 MOD;
     PUT '<script type="text/javascript" language="JavaScript">               ';
     PUT '<!--';
     PUT 'function populateForm() {                   ';
     PUT '     document.CMDETform.mrnI.value = "' mrno '";';
     IF nm_l > ' ' THEN PUT 'document.CMDETform.inf_lname.value = "' nm_l +(-1) '";';
     IF nm_f > ' ' THEN PUT 'document.CMDETform.inf_fname.value = "' nm_f +(-1) '";';
     IF sex > . THEN DO;
        PUT '   for (var i=0;i<document.CMDETform.sex.options.length;i++) {';
        PUT '       if (document.CMDETform.sex.options[i].value == "' sex +(-1) '")';
        PUT '           document.CMDETform.sex.selectedIndex = i;';
        PUT '          }';
     END;
     […]
     PUT '}                                            ';
     PUT '-->';
     PUT '</script>                                    ';
     PUT '</head>';
     PUT '<body style="margin-top:10px; margin-left:2px; margin-right:2px"' @;
     PUT 'onload="javascript:populateForm();">';
     PUT '<form name="CMDETform" action="' "&_URL" '" method="post">';
RUN;
%END;
%ELSE %DO;
 /* go here if there are no observations in sub */
     […]
%END;
[…]
DATA _null_;
     INFILE "&extHTMLpath&sysslash.%LOWCASE(getCaseDetails).html" truncover LRECL=2000;
     FILE out LRECL=2000 MOD;
     INPUT infile $2000.;
     infile = RESOLVE(infile);
     PUT infile;
RUN;
[…]
DATA _NULL_;
     FILE out LRECL=2000 MOD;
     […]
     PUT '<form name="caseManagement" action="' "&_URL" '" method="post">';
     PUT '<input type="hidden" name="ToDo" value="caseManagement" />';
     PUT '<input type="hidden" name="_program" value="progs.nmds.sas" />';
     PUT '<input type="hidden" name="_service" value="' "&_service" '" />';
     PUT '<input type="hidden" name="_debug" value="' "&_debug" '" />';
     PUT '<input type="hidden" name="_sessionid" value="' "&_sessionid" '" />';
     PUT '<input type="hidden" name="keycode" value="' "&keycode" '" />';
     PUT '<input type="hidden" name="userid" value="' "&userid" '" />';
     PUT '<input type="hidden" name="_server" value="' "&_server" '" />';
     PUT '<input type="hidden" name="_port" value="' "&_port" '" />';
     PUT '</form>';
     […]
     PUT '</body>';
     PUT '</html>';
RUN;
[…]
DATA _NULL_;
     FILE _webout;
     URL = &_replay || "caseDetail.html";
     PUT '<script>' /
         'location.replace("' url +(-1) '");' /
         '</script>'
     ;
RUN;
%MEND getCaseDetails;
```

DATA ENTRY – PHASE II

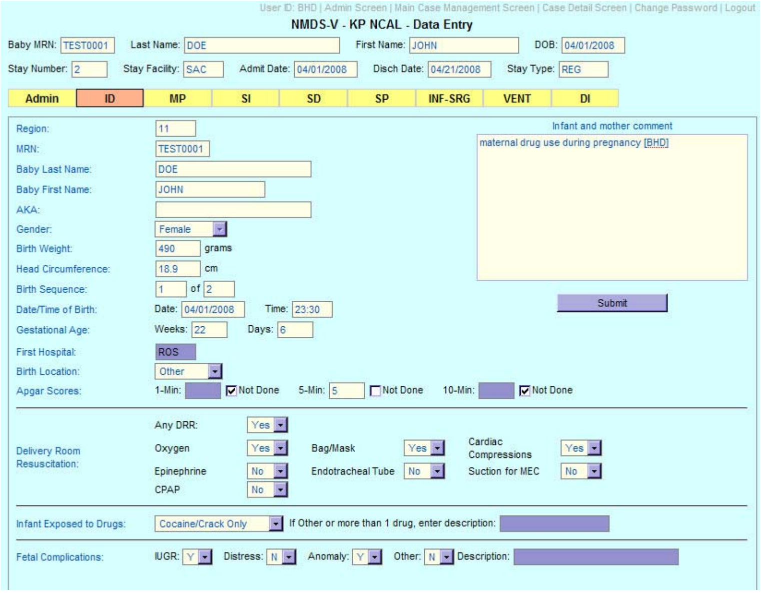
Providing detailed eligibility information via the NMDS-V screen shown in Figure 6 initiates an NMDS record for an eligible infant.

As a customized data entry system, NMDS-V allows several types of eligibility. For instance, an infant might have been in the NICU for less than 24 hours and mostly for observation. This eligibility type will require a different set of forms compared to an acutely ill infant. Depending upon eligibility type, NMDS-V will provide the appropriate set of forms. Note that NMDS-V is a stay based system, in other words, if an infant had stays at several different hospitals, data for each stay is collected separately.

The forms needed to enter stay information for each eligible infant can be accessed in two ways: Through the screen shown in Figure 5 by clicking on the stay number in column 9; or through the screen shown in Figure 6 by clicking on the stay number in the Transport History table.

The screen that opens up once a user has clicked on the stay number is displayed in Figure 7. The top section cannot be edited by a user and is used to display key information on the infant and stay that is currently abstracted. The navigation band highlights the default abstraction form, the ID or Infant Demographic form. The navigation form gives access to all abstraction forms applicable dependent on eligibility type, stay number, and infant disposition.

The HTML needed for each abstraction form is stored on the application server. A user request for a specific form triggers a SAS program on the application server that will load the correct form and generate JavaScript to populate the form with any information that has previously been stored in the NMDS data bases.


User ID: BHD | Admin Screen | Main Case Management Screen | Case Detail Screen | Change Password | Logout
Admin
ID
MP
SI
SD
SP
INF-SRG
VENT
DI
Submit

NMDS-V - KP NCAL - Data Entry

Baby MRN: TEST0001 Last Name: DOE First Name: JOHN DOB: 04/01/2008

Stay Number: 2 Stay Facility: SAC Admit Date: 04/01/2008 Disch Date: 04/21/2008 Stay Type: REG

Region: 11
MRN: TEST0001
Baby Last Name: DOE
Baby First Name: JOHN
AKA:
Gender: Female
Birth Weight: 490 grams
Head Circumference: 18.9 cm
Birth Sequence: 1 of 2
Date/Time of Birth: Date: 04/01/2008 Time: 23:30
Gestational Age: Weeks: 22 Days: 6
First Hospital: ROS
Birth Location: Other
Apgar Scores: 1-Min: ☑ Not Done 5-Min: 5 □ Not Done 10-Min: ☑ Not Done

Infant and mother comment
maternal drug use during pregnancy [BHD]

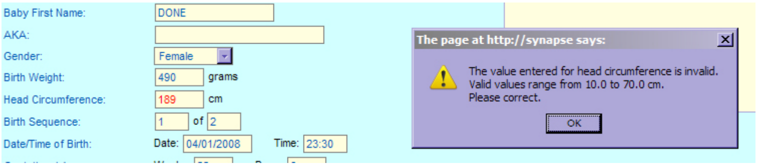
Delivery Room Resuscitation:
Any DRR: Yes
Oxygen: Yes Bag/Mask: Yes Cardiac Compressions: Yes
Epinephrine: No Endotracheal Tube: No Suction for MEC: No
CPAP: No

Infant Exposed to Drugs: Cocaine/Crack Only If Other or more than 1 drug, enter description:

Fetal Complications: IUGR: Y Distress: N Anomaly: Y Other: N Description:

Figure 7: NMDS-V Data Entry - ID Section

JavaScript is also used to verify the consistency of information entered within each section and across sections. Data entry errors are clearly marked as shown in the example in Figure 8.



Baby First Name: DONE
AKA:
Gender: Female
Birth Weight: 490 grams
Head Circumference: 189 cm
Birth Sequence: 1 of 2
Date/Time of Birth: Date: 04/01/2008 Time: 23:30

The page at http://synapse says:

The value entered for head circumference is invalid.
Valid values range from 10.0 to 70.0 cm.
Please correct.

Figure 8: NMDS-V JavaScript Error Checks

Upon submission of each form, hidden form variables route the submission to the SAS application server:

```
   <input type="hidden" name="ToDo" value="updateTheme" />
   <input type="hidden" name="theme" value="ID" />
   <input type="hidden" name="stay_no" value="1" />
   <input type="hidden" name="st_ent_dt" value="" />
   <input type="hidden" name="_program" value="progs.nmds.sas" />
   <input type="hidden" name="_service" value="nmds" />
   <input type="hidden" name="_debug" value="0" />
   <input type="hidden" name="_sessionid" value="Syy1IAyDL52" />
   <input type="hidden" name="_server" value="nmdsserver" />
   <input type="hidden" name="_port" value="51028" />
   <input type="hidden" name="userid" value="XYZ" />
   <input type="hidden" name="thisusertype" value="admn" />
```

A section in the gatekeeper macro `goNMDS.sas` (see page 3) allows us to identify the SAS macros called for each abstraction area:

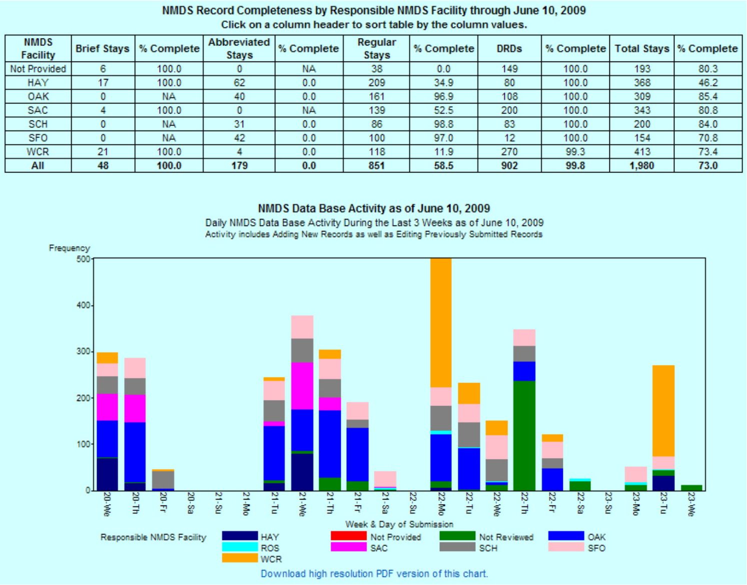
```
   […]
   %ELSE %IF &ToDo EQ updateTheme %THEN %DO;
      […]
      %updateTheme&theme;;;; /* update with information entered by user */
      %doTheme&theme;;;;     /* re-display screen */
   %END;
   […]
```

NMDS-V CONTEXT SENSITIVE HELP

For each item collected on the abstraction form, context sensitive help is available by clicking on the item header. The help information is available as static HTML files residing on the web server; these HTML files are generated using SAS based on the user manual. While the help screen HTML files on the web server have to be updated each time the user manual is changed, the update steps require no user intervention besides running the SAS program and uploading the generated HTML to the web server. As user manual updates are infrequent, this implementation route was easy and acceptable.

INTEGRATED REPORTING ON DATABASE ACTIVITY AND ON NICU STATISTICS

Users with administrator rights can at any time generate current database activity reports. The reports show the volume of infants likely eligible, partially, and fully abstracted by user, NMDS facility, and other key variables. An excerpt of the report is shown in Figure 9.



NMDS Record Completeness by Responsible NMDS Facility through June 10, 2009
Click on a column header to sort table by the column values.

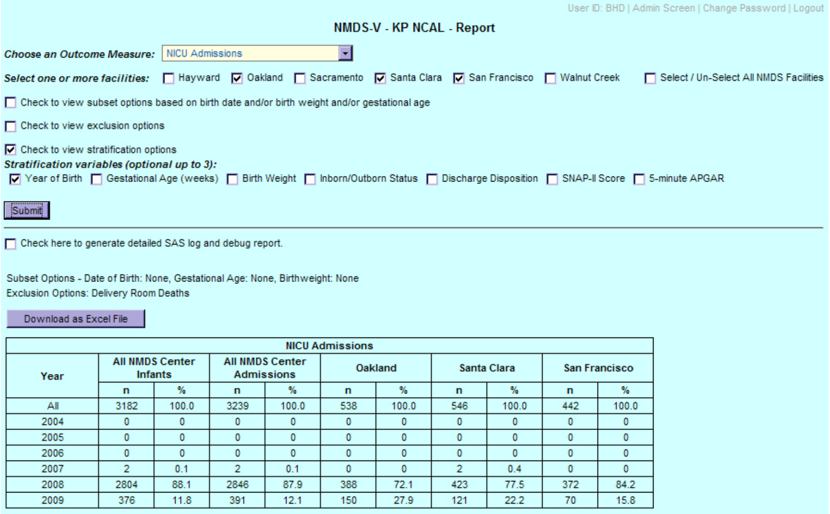
NMDS Facility	Brief Stays	% Complete	Abbreviated Stays	% Complete	Regular Stays	% Complete	DRDs	% Complete	Total Stays	% Complete
Not Provided	6	100.0	0	NA	38	0.0	149	100.0	193	80.3
HAY	17	100.0	62	0.0	209	34.9	80	100.0	368	46.2
OAK	0	NA	40	0.0	161	96.9	108	100.0	309	85.4
SAC	4	100.0	0	NA	139	52.5	200	100.0	343	80.8
SCH	0	NA	31	0.0	86	98.8	83	100.0	200	84.0
SFO	0	NA	42	0.0	100	97.0	12	100.0	154	70.8
WCR	21	100.0	4	0.0	118	11.9	270	99.3	413	73.4
All	**48**	**100.0**	**179**	**0.0**	**851**	**58.5**	**902**	**99.8**	**1,980**	**73.0**

NMDS Data Base Activity as of June 10, 2009
Daily NMDS Data Base Activity During the Last 3 Weeks as of June 10, 2009
Activity includes Adding New Records as well as Editing Previously Submitted Records

Download high resolution PDF version of this chart.

Figure 9: NMDS-V Activity Report Excerpt

The database activity report can be used to track the number of records in the data base along with abstractor progress.



User ID: BHD | Admin Screen | Change Password | Logout

NMDS-V - KP NCAL - Report

Choose an Outcome Measure: NICU Admissions

Select one or more facilities: □ Hayward ☑ Oakland □ Sacramento ☑ Santa Clara ☑ San Francisco □ Walnut Creek □ Select / Un-Select All NMDS Facilities

□ Check to view subset options based on birth date and/or birth weight and/or gestational age

□ Check to view exclusion options

☑ Check to view stratification options

Stratification variables (optional up to 3):
☑ Year of Birth □ Gestational Age (weeks) □ Birth Weight □ Inborn/Outborn Status □ Discharge Disposition □ SNAP-II Score □ 5-minute APGAR

□ Check here to generate detailed SAS log and debug report.

Subset Options - Date of Birth: None, Gestational Age: None, Birthweight: None
Exclusion Options: Delivery Room Deaths

NICU Admissions

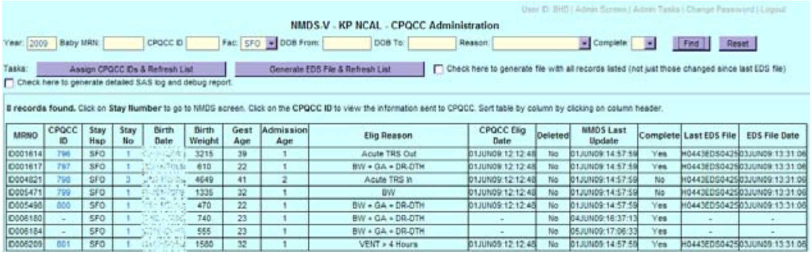
Year	All NMDS Center Infants		All NMDS Center Admissions		Oakland		Santa Clara		San Francisco	
	n	%	n	%	n	%	n	%	n	%
All	3182	100.0	3239	100.0	538	100.0	546	100.0	442	100.0
2004	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0
2007	2	0.1	2	0.1	0	0	2	0.4	0	0
2008	2804	88.1	2846	87.9	388	72.1	423	77.5	372	84.2
2009	376	11.8	391	12.1	150	27.9	121	22.2	70	15.8

Figure 10: NMDS-V Analytic Report

NMDS-V allows analytic reports on NICU volumes as well as a variety of process and outcome measure of NICU performance such as use of antenatal steroids, nosocomial infections, surfactant treatment, chronic lung disease, surgeries, ROP, etc. The report allows several customization options. As the data base reporting module had secondary priority, this is the area that will see the most changes and improvements in the coming year.

INTEGRATED SUPPORT OF DATABASE GENERATION TO MEET NEEDS OF MULTIPLE CONSTITUENTS

One major goal of the NMDS-V application was support of the generation of secondary databases needed for the participation in national QI programs. One such program is the California Perinatal Quality Care Collaborative (CPQCC) (http://www.cpqcc.org). All NMDS-V Kaiser facilities participate in this QI effort. One participation requirement is the submission of information on selected NICU infants. The automatic generation of CPQCC compliant data bases has been fully integrated into NMDS-V (see Figure 10). NICU infant eligibility for CPQCC, ID assignment for the purpose of CPQCC, data updates, and CPQCC record management is accessible through the CPQCC management administrator feature. This integration alone has saved hundreds of data entry hours.


User ID: BHD | Admin Screen | Admin Tasks | Change Password | Logout
Find
Reset
Assign CPQCC IDs & Refresh List
Generate EDS File & Refresh List

NMDS-V - KP NCAL - CPQCC Administration

Year: 2009 Baby MRN: CPQCC ID: Fac: SFO DOB From: DOB To: Reason: Complete:

Tasks:

□ Check here to generate file with all records listed (not just those changed since last EDS file)

□ Check here to generate detailed SAS log and debug report.

8 records found. Click on **Stay Number** to go to NMDS screen. Click on the **CPQCC ID** to view the information sent to CPQCC. Sort table by column by clicking on column header.

MRNO	CPQCC ID	Stay Hsp	Stay No	Birth Date	Birth Weight	Gest Age	Admission Age	Elig Reason	CPQCC Elig Date	Deleted	NMDS Last Update	Complete	Last EDS File	EDS File Date
ID001614	796	SFO	1	[redacted]	3215	39	1	Acute TRS Out	01JUN09:12:12:48	No	01JUN09:14:57:59	Yes	H0443EDS0425	03JUN09:13:31:06
ID001617	797	SFO	1	[redacted]	610	22	1	BW + GA + DR-DTH	01JUN09:12:12:48	No	01JUN09:14:57:59	Yes	H0443EDS0425	03JUN09:13:31:06
ID004821	798	SFO	3	[redacted]	4649	41	2	Acute TRS In	01JUN09:12:12:48	No	01JUN09:14:57:59	No	H0443EDS0425	03JUN09:13:31:06
ID005471	799	SFO	1	[redacted]	1335	32	1	BW	01JUN09:12:12:48	No	01JUN09:14:57:59	No	H0443EDS0425	03JUN09:13:31:06
ID005498	800	SFO	1	[redacted]	470	22	1	BW + GA + DR-DTH	01JUN09:12:12:48	No	01JUN09:14:57:59	Yes	H0443EDS0425	03JUN09:13:31:06
ID006180	-	SFO	1	[redacted]	740	23	1	BW + GA + DR-DTH	-	No	04JUN09:16:37:13	Yes	-	-
ID006184	-	SFO	1	[redacted]	555	23	1	BW + GA + DR-DTH	-	No	05JUN09:17:06:33	Yes	-	-
ID006209	801	SFO	1	[redacted]	1580	32	1	VENT > 4 Hours	01JUN09:12:12:48	No	01JUN09:14:57:59	Yes	H0443EDS0425	03JUN09:13:31:06

Figure 11: NMDS-V Integrated CPQCC Administration

Another data collection and reporting requirement handled by NMDS-V is a transport component (California Perinatal Transport System, CPeTS) collecting additional data on acute infant transports. Additionally, the NMDS-V datasets are used to generate hundreds of ad hoc reports on clinical indicators of interest to perinatal clinicians and organizational leadership at the individual hospital and aggregate (regional) levels.

NEXT STEPS

After successfully implementing the core set of features integration of legacy data and additional reporting functions will expand the usefulness of NMDS-V within the next year.

CONCLUSION

The application was developed in the time frame required and went into production in February 2008. It has been endorsed with enthusiasm by the various staff layers involved. Thus far the choice of SAS for all data management and reporting function has been shown to be a stable and dynamic choice.

Depending upon an organization’s needs and level of expertise with SAS, our experience has shown that relying on SAS Foundation Technologies for all aspects of data collection, analysis, and reporting and combined with basic web design tools HTML, JavaScript, and CSS can be a very successful venture, integrating multiple functions in a seamless design with stable performance for multiple simultaneous users.

RECOMMENDED READING

1. Hendersen D. *Building Web Applications with SAS/IntrNet: A Guide to the Application Dispatcher.* SAS Press, 2007.
2. Pratter F. *Web Development with SAS by Example.* SAS Press, 2nd Edition, 2006.
3. Carpenter A. *Carpenter's complete guide to the SAS macro language*, SAS Press, 2nd Edition, 2004.
4. Flanagan D. *JavaScript: The Definitive Guide.* O’Reilly Media, 5th Edition, 2006.
5. Musciano C, Kennedy B. *HTML & XHTML: The Definitive Guide*. O’Reilly Media, 6th Edition, 2006.

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