



UPPSALA  
UNIVERSITET

Department of Information Technology

Human-Computer Interaction Final Project:

Uppsala County Ambulance Service  
Quality Assurance System Interface Design

Douglas Spangler

## Background

The Uppsala county ambulance service consists of 91 full-time ambulance nurses (Internal, 2015) and support staff serving a population of 354 000 (SCB, 2015), responding to roughly 40 000 emergency calls per year (Internal, 2015). The agency currently relies on an Incident Reporting (IR) system to assure the quality of patient care as required by Swedish law (SFS 2010:659). The agency currently has access to data from both the Emergency Medical Dispatch (EMD) center and electronic Patient Care Report (ePCR) data from records captured in the field by ambulance nurses. Work to prospectively import patient outcome data from the county Electronic Health Record (EHR) system is ongoing. The potential to implement an information system to manage the Incident Reporting workflow and incorporate the data available from the various data streams into the quality assurance system was identified by the author in the course of working on other data-related projects.

While the current quality assurance system is widely perceived as adequate given the low volume of IRs submitted, and there is robust oversight via The Health and Social Care Inspectorate (IVO), research has cast doubt on the ability of manual reporting systems to comprehensively capture incidents which may affect patient safety (Lawton and Parker 2002; Sari et al. 2007; Stanhope et al. 1999). Systematic quality improvement programs were found in a joint WHO-IATSIC review to consistently “improve the process of care, decrease mortality, and decrease costs” in trauma systems (Juillard et al. 2009), and interest in such methods within the field of pre-hospital care is substantial. Given the availability of the requisite linked patient care data at the Uppsala county ambulance service, a study was commenced to establish requirements and specifications for an information system to support the internal Quality Assurance and Improvement (QA/QI) activities.

## Methodology

A literature review was performed to ascertain industry best practices regarding QA/QI system design, applications and workflows (Provost and Murray 2011; Ross 2013). The establishment of quality metrics was found to be critical to the implementation of Quality Management systems. A set of quality metrics based on measures from a number of international sets (Murphy et al. 2016; NHS England; California Emergency Medical Services Authority) was developed for the ambulance service. While a fully scoped system would require the ability to generate metrics and include tools to analyze data, it was decided to focus the initial development work on the sub-system necessary for staff to use these metrics in the day-to-day QA review process.

An initial system overview was created based on a user analysis as described by Blomkvist (TH 4) and (Benyon 2010). The user analysis resulted in the identification of three major classes of users. Semi-structured interviews were conducted with staff at the ambulance service representing each of these groups to obtain their impressions of the current system and desired functionality in the proposed system:

- Medical control – This group consists of individuals responsible for determining the criteria for including records in the Quality Assurance process, bear the ultimate responsibility for providing high-quality patient care within their organizations. These users have moderate technical competence, and will be trained in the use of the system. The agency Medical

Director (MD) was interviewed.

Goals: Maintain accountability, verify that process results in improvements

- Quality Assurance reviewers – This group consists of users responsible for the day-to-day monitoring of the Quality Assurance system, reviewing records, and taking action upon identifying records requiring an intervention. These users have moderate technical competence, and will be trained in the use of the system. The agency Education Coordinator (EC) responsible for managing the current QA system was interviewed.

Goals: Complete reviews with minimum time/effort, use results in education

- Field Staff – This group consists of the Ambulance personnel whose documentation will be reviewed using the QA system. These users have a highly varied degree of technical expertise, and will not be trained in the use of the system. A small group of ~5 Ambulance Nurses (AN) were interviewed.

Goals: Obtain feedback about outcomes, minimize documentation time

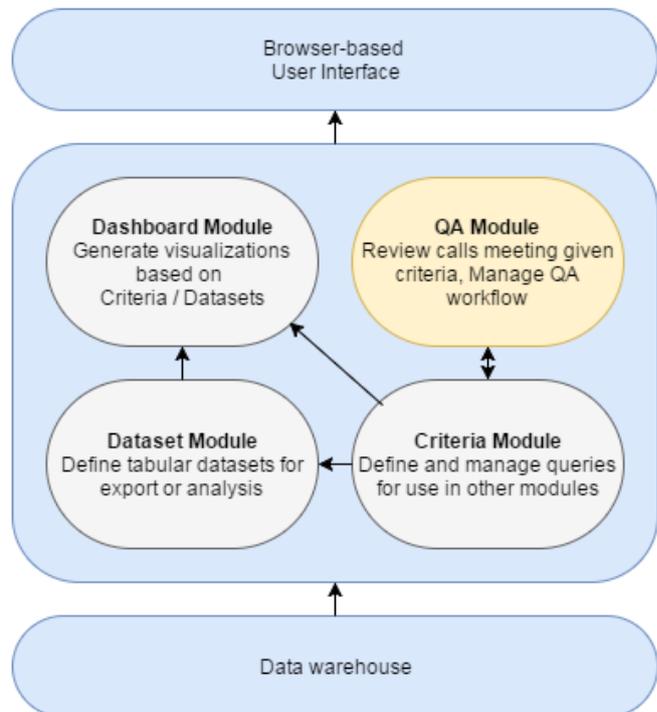
A set of scenarios representing likely workflows based on these desires were envisioned. Note that henceforth, a “call” will refer to a single ambulance incident, while a “record” will refer to an entry in the QA database (ie., a match between a criteria and a call) – A call can meet multiple criteria and thus result in several QA records for instance.

- MD requests review of Trauma scene times
  - MD identifies that scene times for trauma incidents at their agency exceed the national average.
  - MD creates metric to identify records with a primary impression of Trauma and a scene time exceeding 20 minutes.
  - MD assigns EC to review calls meeting the criteria for review
  - EC accesses an interface listing all records assigned to them
  - EC is able to view all data associated with a call, record notes about the reason for the extended scene time and categorize the final disposition of the record.
  - MD and EC review data and identify the important factors associated with extended scene times, and determine if any are suitable to address via a QI project.
- MD requests review of protocol deviations
  - MD reviews protocols to identify important procedures which must be performed under a given circumstance (eg. The administration of Cordarone after three defibrillation attempts in Cardiac Arrest, administration of fluids with a Systolic Blood Pressure < 80)
  - MD creates metrics to identify instances where compliance with protocol was not documented.
  - MD assigns EC to review as per above, but desires that these be reviewed quickly.
  - EC records reason for protocol deviation, and identifies need for additional training or correction of poor documentation.
- AN submits an Incident Report
  - A miscommunication between the ambulance crew and ED nurse occurs upon handoff of a patient who later dies in the ED.

- AN submits an IR to the county information system, which automatically forwards data to the agency QA/QI system.
- A notification is sent to the EC, and an entry appears on the interface noted above containing information about the associated call and nature of the incident
- EC reviews record and notes provided by AN, takes any necessary corrective actions, and records a response to the IR.
- The agency system forwards response data to the county information system.
- Process is repeated if multiple responses are required.

### System overview

This specification describes one module out of the several required in a fully-featured QA/QI system. The QA Module as shown on the right is the portion of the system which would involve the most routine user interaction, and as such is the most vital when considering the development of streamlined workflows. Given this restriction, this specification will assume that important downstream and upstream functionality is specified elsewhere. The Criteria module will allow a user to design the metrics and performance measures described in the scenarios above. The dashboard module will allow for the direct analysis of healthcare data, as well as data generated in the course of using the QA module. The Dataset module allows the user to generate tabular datasets from the underlying structured data related to records meeting given criteria. Within the QA Module, 3 interfaces were determined to be required to accomplish the tasks described in the scenarios above. These include:



**1 – Criteria Assignment** – This interface is used to manage the assignment of criteria to specific reviewers. This view will be limited through a user permission system to “supervisors” typically members of the medical control user class, or manager level staff among the QA Reviewers. It must include the ability to:

- Select among criteria designed in the Criteria Module
- Display records matching the selected criteria with some basic information regarding the call (Timestamp, Call number, Unit designation, Call type, etc.) in a tabular format.
- Filter records based on various criteria.
- Open and view individual records using interface 3.
- Assign an individual, multiple or all new records meeting the selected criteria on an ongoing basis to specific users.

**2 – Review Queue** – This interface allows users to view a list of records assigned to them via the previous interface. This interface will be similar in format and function to the first interface. Instead

of assigning calls to users however, users are limited to assigning a Status to records. A number of statuses should be available for all records, including a default status of “Unreviewed”. Others may include “Complete”, “In progress”, “Awaiting response”, and other dispositions configurable by the agency.

**3 – Record View** – This interface allows the user to view all of the information stored in the database in regards to a particular record, including dispatch, ambulance journal and hospital outcome data. For the purposes of this specification, it is assumed that data will be entirely defined by the [NEMISIS 3 data standard](#). In addition to viewing the contents of individual records, the user should be able to perform all actions available to them via the previous interfaces, and type free-text notes regarding the record.

### Interface design

Interfaces 1 and 2 are closely related, with the Review Queue being essentially a functionally limited version of interface 1. As noted by Axelsson in TH3, such Perceptual, Semantic and Procedural consistency is critical to the user’s ability to rapidly build and maintain a mental model of the information presented to them. The only perceptually inconsistent elements should be those intended to capture the user’s attention, such as the priority level of the record (Displayed for instance as red for Critical and yellow for High priority records). The top bar contains tools to manipulate a set of records. In interface 1, a supervisor may select among 4 fields. Of these, only the Criteria selection dropdown will automatically filter the view (a). The remainder are used to assign calls meeting that criteria to a certain user, with a certain status at a certain priority (the default “unreviewed” status and no priority is assigned if no selection is made). “None” and “Documenter” will be the first two options in the User dropdown list(b), the selection of which allows the supervisor to un-assign records and assign records to the user who wrote the report respectively. Upon selecting the appropriate fields, the user can choose to assign all of the selected calls to the chosen user or assign all future calls to the selected user on a prospective basis(c). Upon selecting an action which affects more than 1 record, a warning dialogue box will pop up asking to confirm their action. The user may also choose to assign specific records to users/statuses by using the dropdowns and buttons along the right hand side of the screen(d). Upon task analysis, it was

1 - Criteria Assignment

Record #	Date	Call Type	Criteria	QA Status	User
163539	06-10-16	Trauma	Scene Time	Unreviewed	EC
162834	04-10-16	Trauma	Scene Time	Unreviewed	EC
160937	04-10-16	Arrest	Cordarone	Unreviewed	EC
169354	25-09-16	Trauma	Scene Time	In progress	EC
164958	24-09-16	Arrest	Cordarone	Unreviewed	Select User...
169382	20-09-16	Trauma	Scene Time	Unreviewed	Select User...

Filter: Date Range... QA Status... User... Priority...

2 - Review Queue

Record #	Date	Call Type	Criteria	Assigned by	QA Status
163539	06-10-16	Trauma	Scene Time	MD	Unreviewed
162834	04-10-16	Trauma	Scene Time	MD	Unreviewed
160937	04-10-16	Arrest	Cordarone	MD	Unreviewed
169354	25-09-16	Trauma	Scene Time	MD	In progress

Filter: Date Range... QA Status... Criteria... Priority...

noted that the ability to undo an action was desired, and this was added to the design. This button will undo the last data manipulation action (ie., not filter selections). Immediate access to a help function was added to each screen as well and this, along with the undo and settings buttons form a set of global actions available from any interface(e).

Users are able to select records using the buttons along the left hand side of the screen for use in tandem with the actions bar(f). Users are able to directly access interface 3 displaying a given call using the View button(g). Along the bottom of the screen are filters used to restrict the calls displayed(h). The list of filters is limited to only those used commonly in the agency's everyday QA work, and more complex searches are expected to be performed using the Criteria module, from which they can be assigned for review.

By default, the interfaces will list all records in the system viewable by the user in descending chronological order (ie, most recent first). Records can be sorted by a certain field by clicking the appropriate column header. While interface 1 displays the user assigned to a record, interface 2 displays instead the supervisor who assigned the record(i). These interfaces are designed to allow the user to expose the data necessary to the development of a mental model of the systems relevant to their activities within the QA process as described in (Benyon 2010, 32).

Interface 3 will be accessible from both interfaces 1 and 2 to enable detailed scrutiny of a call. The interface will be identical for these users, except for the availability of the Criteria and User action menus and the Assign to All Criteria button (j, dotted red outline). The actions available are the same, with the addition of the ability to perform the action on all records pertaining to the call. To maintain consistency with interfaces 1 and 2, manipulative

The screenshot displays the '3 - Record View' interface. At the top, there is a ribbon of information: Record # 160937, Date: 04-10-16, Call type: Arrest, Criteria: Cordarone, and Status: Unreviewed. Below this, a patient information section shows details for 'ePatient' with fields for EMS Patient ID (sT), Patient Name Group, and a table for Patient Name (Last Name: Baldwin, First Name: Alejandro, Middle Initial: Amaral). Other fields include Patient's Home Address (3427 Sodales Road), Patient's Home City (Nibley), Patient's Home County (Cache), Patient's Home State (Utah), and Patient's Country of Residence (US). A 'Notes' section at the bottom contains the text: 'Spoke with crew, noted that Cordarone was administered but not documented'. The interface includes various action buttons and dropdown menus, some of which are circled in red and labeled with letters: 'j' (Assign to all Criteria), 'o' (Assign), 'p' (Patient Name table), 'l' (Other Criteria dropdown), 'm' (Jump to section), 'n' (Save View), and 'k' (Notes field).

actions are placed at the top of the screen, while functions to manage the information presented to the user is at the bottom, along with a field to record notes about the call(k). This text is autosaved to the server on a regular basis. If the call meets multiple criteria, the user will be able to move between these using the Other Criteria dropdown(l), and the user is able to jump directly to different sections of the call data(m). The User is able to save their current view of the screen and select from a list of previously defined views(n), to be described shortly.

A ribbon of basic information about the record is presented above the main view(o). This information is presented in the same manner as in interfaces 1 and 2. The page below this will be procedurally generated from the NEMIS 3 structured XML data stored in the database. The [sample data](#) used to generate this mockup were retrieved from the NEMIS TAC Website (folder structure SampleData.zip/EMS/xml/EMSDataset-ElementsRepeat-1.xml). Nested data elements will alternate between splitting items between rows and columns(p). The Element name and value will be

displayed, and additional information (eg., expected value parameters, tag information, other items from XSD) will be displayed upon mouseover. Element values based on lookup tables will be automatically transformed to plaintext. Parent nodes can be collapsed using minus buttons(q), and the current configuration of collapsed/uncollapsed nodes can be saved along with the current position on the page as a view. Upon saving a view, a dialogue box will request that the user provide a name and select if the user wishes to set this as their default view, default view for this criterion, or just save it.

### **Design Considerations**

The review of healthcare records can be a highly demanding task, but this design attempts to alleviate the burden of routine tasks, and allow the user to investigate records with minimum time and effort spent navigating the interface. Kavathatzopoulos notes in TH 8 that short term memory is highly limited, and as such interfaces must be designed to present the information salient to a decision within a short time-span, or allow the user to easily record and recall information. To further this, the notes field is integrated into the page frame, rather than placed at the bottom of the record to ensure that thoughts can be saved quickly and without jumping around the page. Efforts were made to streamline this portion of the system, offloading the complexity necessary to generate the often convoluted inclusion criteria often used by performance measures to the Criteria module, intended for use by trained power users. For instance, from the point at which the criteria is added to the system and users are logged in, the task in scenario 1 can be completed by the MD in 3 clicks, and each record reviewed by the EC in 3 clicks, plus the typing necessary to add notes.

A configuration page should be available to edit what call information is presented in interfaces 1 and 2, as well as in the information ribbon in interface 3, along with the ability to manage saved Views for interface 3. This screen should make available to Supervisor level users the ability to manage existing prospective criteria assignments. Using the configuration screen, supervisors should be able to manage notifications sent to users via email automatically by the system, and the option to associate notification settings with priority levels should be available (eg., Critical priority records send an email notification immediately upon assignment, and a follow-up email every 7 days without a change to the record's data). Supervisors should have the ability to create Status categories and assign them as a default option, or to specific criteria. If the system is configured to assign records to documenting crew members, it is likely that a more limited set of permissions will have to be implemented so as to accommodate these users' more varied level of technical competence and limited training.

While integration with the County information system was in this case necessary, a new IR submission process was desired by staff at the ambulance agency, noting that the current process was slow and unreliable. A new submission and notification system based on secure email accounts was deemed desirable but infeasible due to the accountability requirements satisfied through the use of the current centralized system. Interoperability with this system was assumed to be achievable. All actions taken in the system should result in a log entry to ensure accountability. These logs can then be queried using the Criteria module and, if desired, fed back into the QA system (eg., assignment of a criteria identifying all records with a status of "Complete, crew training needed"). QA records should be accessible in the Dashboard interface to enable analysis based on

QA findings which can lead to the initiation of projects to improve the quality of care provided in relation to weaknesses identified through the QA process.

#### References:

- Benyon, David. 2010. *Designing Interactive Systems: A Comprehensive Guide to HCI and Interaction Design*. Pearson Education M.U.A.
- California Emergency Medical Services Authority. 2016. "EMS Core Quality Measures Project." Accessed October 6. [http://www.emsa.ca.gov/ems\\_core\\_quality\\_measures\\_project](http://www.emsa.ca.gov/ems_core_quality_measures_project).
- Juillard, Catherine J., Charles Mock, Jacques Goosen, Manjul Joshipura, and Ian Civil. 2009. "Establishing the Evidence Base for Trauma Quality Improvement: A Collaborative WHO-IATSIC Review." *World Journal of Surgery* 33 (5): 1075–86. doi:10.1007/s00268-009-9959-8.
- Lawton, R., and D. Parker. 2002. "Barriers to Incident Reporting in a Healthcare System." *Quality and Safety in Health Care* 11 (1): 15–18. doi:10.1136/qhc.11.1.15.
- Murphy, Adrian, Abel Wakai, Cathal Walsh, Fergal Cummins, and Ronan O'Sullivan. 2016. "Development of Key Performance Indicators for Prehospital Emergency Care." *Emergency Medicine Journal* 33 (4): 286–92. doi:10.1136/emered-2015-204793.
- NHS England. n.d. "Ambulance Quality Indicators." <https://www.england.nhs.uk/statistics/statistical-work-areas/ambulance-quality-indicators/>.
- Provost, Lloyd P., and Sandra Murray. 2011. *The Health Care Data Guide: Learning from Data for Improvement*. Jossey-Bass.
- Ross, Thomas K. 2013. *Health Care Quality Management : Tools and Applications*. Somerset, US: Jossey-Bass. <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10822371>.
- Sari, Ali Baba-Akbari, Trevor A. Sheldon, Alison Cracknell, and Alastair Turnbull. 2007. "Sensitivity of Routine System for Reporting Patient Safety Incidents in an NHS Hospital: Retrospective Patient Case Note Review." *BMJ* 334 (7584): 79. doi:10.1136/bmj.39031.507153.AE.
- Svensk Författningssamling 2010. *Patientsäkerhetslag. 2010:659*. [https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/patientsakerhetslag-2010659\\_sfs-2010-659](https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/patientsakerhetslag-2010659_sfs-2010-659).
- Stanhope, Nicola, Margaret Crowley-Murphy, Charles Vincent, Anne M O'Connor, and Sally E. Taylor-Adams. 1999. "An Evaluation of Adverse Incident Reporting." *Journal of Evaluation in Clinical Practice* 5 (1): 5–12. doi:10.1046/j.1365-2753.1999.00146.x.

Appendix 1 – Full size mockups

1 - Criteria Assignment

Select Criteria... ▼

Select User... ▼

Assign All Future

1-6 of 6

Select QA Status... ▼

Select Priority... ▼

Assign All Selected

< >

↶

?

⚙

<input type="checkbox"/>	Record #	Date	Call Type	Criteria	QA Status	User
<input checked="" type="checkbox"/>	<a href="#">View</a> 163539	06-10-16	Trauma	Scene Time	Unreviewed	EC <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 162834	04-10-16	Trauma	Scene Time	Unreviewed	EC <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 160937	04-10-16	Arrest	Cordarone	Unreviewed	EC <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 169354	25-09-16	Trauma	Scene Time	In progress	EC <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 164958	24-09-16	Arrest	Cordarone	Unreviewed	Select User... <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 169382	20-09-16	Trauma	Scene Time	Unreviewed	Select User... <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>

Filter: Date Range... ▼ QA Status... ▼ User... ▼ Priority... ▼

2 - Review Queue

Select QA Status... ▼

Select Priority... ▼

Assign All Selected

1-4 of 4

< >

↶

?

⚙

<input type="checkbox"/>	Record #	Date	Call Type	Criteria	Assigned by	QA Status
<input checked="" type="checkbox"/>	<a href="#">View</a> 163539	06-10-16	Trauma	Scene Time	MD	Unreviewed <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 162834	04-10-16	Trauma	Scene Time	MD	Unreviewed <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 160937	04-10-16	Arrest	Cordarone	MD	Unreviewed <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>
<input type="checkbox"/>	<a href="#">View</a> 169354	25-09-16	Trauma	Scene Time	MD	In progress <span style="font-size: 0.8em;">▼</span> <span style="border: 1px solid #ccc; border-radius: 5px; padding: 2px 5px;">Assign</span>

Filter: Date Range... ▼ QA Status... ▼ Criteria... ▼ Priority... ▼

### 3 - Record View

Select Criteria... ▾ Select User... ▾ Assign to all Criteria

Select QA Status... ▾ Select Priority... ▾ Assign

↶ ? ⚙

Record #: 160937 Date: 04-10-16 Call type: Arrest Criteria: Cordarone Status: Unreviewed

⊖ ePatient

EMS Patient ID <b>sT</b>		
⊖ PatientNameGroup		
Last Name	First Name	Middle Initial/Name
<b>Baldwin</b>	<b>Alejandro</b>	<b>Amaral</b>

Patient's Home Address **3427 Sodales Road**

Patient's Home City **Nibley**

Patient's Home County **Cache**

Patient's Home State **Utah**

Patient's Country of Residence **US**

Notes: Other Criteria... ▾ Jump to section... ▾ Select View... ▾ Save View View Next

Spoke with crew, noted that Cordarone was administered but not documented