

# ***Technologies for Enhancing Clinical Information Systems***

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# Our Strategic Objectives

1. Deliver **NLP Enhancement Technologies** for intelligent support and processing.
2. Build generic, compact, customisable Clinical ISs to enhance existing clinical processes.
3. Position Natural Language Processing as the base technology for processing the EMR

*“all clinical data has to be turned into language”*

# Our HIT Activities

- 60+ Projects in 3 Years
- Language Analysis of clinical texts
- Data Analytics for Clinical ISs
- Text to SNOMED CT to ICD 10AM
- Generating subset of SNOMED CT
- Clinical Information Systems - WeBCIS
- Rescuing data from abandoned and decaying ISs - OMNI-LAB, HOS-LAB, CARDS, BS, HOSREP.
- Partners: RPAH, SEALS, NCCH, SWAHS, Childrens Westmead, SWAPS, and more

# Enhancement Technologies

## Active Projects

1. Ward Rounds Information Systems
2. Clinical Data Analytics Language
3. Structured Reporting - Pathology+ Imaging
4. Handovers Information System

# 1. Ward Rounds Information System (WRIS)

- Needs
  - Make an extract of the current medical measurements into a pro forma report
  - Congregate at patient bedside
  - Determine next course of action
  - Record those actions in the medical record
  - Complete an analysis of the narrative content for indexing

## GICU WARD ROUND

### \*\*\*\*INITIAL DIAGNOSES AND RELEVANT BACKGROUND\*\*\*\*

### \*\*\*\*ASSESSMENT\*\*\*\*

#### NEUROLOGICAL

Sedation:  
GCS: V 4 M 8 E 4 = 14 (12:00)

#### RESPIRATORY

Ventilation: Vent. Mode: Ven.msk RR 0 Vt 0 PS 0 PEEP 0 FIO2 0.00  
PaCO2 34 (07:00) PaO2 78 (07:00) pH 7.25 (07:00) BE -12.0 (07:00)  
Chest Tube Total NIL

#### Chest Examination:

#### CARDIOVASCULAR

HR 96 MAP 76 CVP 8  
Inotropes:  
8mg Noradrenaline 5 mcg/kg/min  
Lactate ABG 0.8 (07:00)

#### CVS Examination:

GICU WARD ROUND - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/interface.php?templatetype=1&mrn=[REDACTED]&submit=Populate

CareVue Thin Web

The University of Sydney Australia

School of Information Technologies Health Informatics Research Group

## GICU-AM Ward Round - [REDACTED]

### GICU WARD ROUND

[REDACTED]

\*\*\*\* INITIAL DIAGNOSES AND RELEVANT BACKGROUND \*\*\*\*

asthma  
heart disease  
NIDDM

\*\*\*\* ASSESSMENT \*\*\*\*

#### NEUROLOGICAL

Sedation:  
GCS: V 1 M 6 E 3 = 10 (12:00)  
**Neuro Examination:**  
No sedation.  
GCS 10  
PEARL 3mm brisk  
Normal power all limbs

#### RESPIRATORY

Ventilation: Vent. Mode: PS RR 22 Vt 353 PS 07 PEEP 10 FiO2 0.30  
PaCO2 48 (13:02) PaO2 91 (13:02) pH 7.37 (13:02) BE 2.0 (13:02)  
**Chest Examination:**  
Bilateral air entry.  
Clear breath sounds.  
Small amount of blood stained sputum.  
RR good

#### CARDIOVASCULAR

HR 105 MAP 93 CVP 11  
Inotropes:  
Lactate ABG 1.5 (13:02)

#### GASTRO-INTESTINAL

Bowels last open: NIL

start Services GICU WARD R... CareVue Thin ... SourceForge.n... 2 Exceed for ... C:\Python24\Li... G:\clinnote ma... 15:25

Template Submission Result - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/html/rpa\_icu.cgi#qual11

CareVue Thin Web

**Abdo Examination:**  
 No bowel sounds.  
 Abdo tender, distended.  
 NGT free drainage with small output.  
 \*\*\*\* CURRENT PROBLEM LIST \*\*\*\*  
 Resolving sepsis.  
 Poor GCS with no sedation  
 Resolving bowel obstruction.  
 \*\*\*\* PLAN \*\*\*\*  
 Remain intubated.  
 Allow to wake.  
 Abdo xray.  
 Trial small amount of NG feed, 2Cal @ 20ml/hr

## Medical terms

ref	Extract	SNOMED-CT	Correct
^	asthma	195967001 Asthma (disorder)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	disease	84572001 Disease (disorder)	<input type="radio"/> Y <input type="radio"/> N <input checked="" type="radio"/> O <input type="radio"/> U
^	NIDDM	44054006 Diabetes mellitus type 2 (disorder)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	power	73618007 Power saw, device (physical object)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	limbs	68019005 Limb structure (body structure)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
		243996003 Entire limb (body structure)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	air	15158005 Air (substance)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
		417896007 Medical air (product)	<input type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	breath sounds	52853008 Respiratory sounds (observable entity)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	blood	32873005 Bloods (ethnic group)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
		87812001 Blood (substance)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
	stained	45389009 Tissue stain (substance)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^		81789006 Dye (substance)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
		397165007 Stain (substance)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	sputum	45710003 Sputum (substance)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	No bowel (absent of) *	87042004 Bowel sounds (observable entity)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	sounds	87042004 Bowel sounds (observable entity)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	drainage	75823008 Discharge (morphologic abnormality)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
		122462000 Drainage procedure (procedure)	<input type="radio"/> Y <input checked="" type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	sepsis	91302008 Systemic infection (disorder)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	bowel obstruction	81080008 Intestinal obstruction (disorder)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U
^	intubated	52785003 Intubation (procedure)	<input checked="" type="radio"/> Y <input type="radio"/> N <input type="radio"/> O <input type="radio"/> U



# Use of SCT Encoding of Clinical Notes

- Indexes notes for SNOMED codes
- Operational Information Retrieval
- Research Information Retrieval
- Data Analytics
- Audit of Care
- Clinician training for stable terminology
- Extension to Customisable Handovers ISs

## 2. A Clinical Data Analytics Language - CDAL

- Principles
  - Can express all questions that are answerable from the database including from narrative content
  - Can compute all questions that can be expressed
  - Is transportable across all CISs

# Clinical Data Analytics Language (CDAL)

- Practicals
- Need for general purpose Information Extraction
  - Over aggregated data
  - Constrained by many variables
  - Over the text notes in the patient record
  - From a wide range of Information Systems
  - Using a wide range of health dialects

# CDAL Request Basic Structure

- Nominates
  - TOCs
  - Databases
  - Statistical/Record Expression
  - Patient Classes
  - Medical Expressions
  - Time constraints
  - Location Constraints
- {Using <SNOMED>}\* in {<ICU-db>}#  
Find <AVG (Stay)> of <children under 12>+ {with <3<sup>rd</sup> degree burns to the torso treated with penicillin>}\*  
{<during the last 2 years>}# from {<postcodes 2300-2999>}#  
\*, # - parameters need to be domain consistent  
+ - classes needs to be computable; Group/Computed functions

CareVue Thin Web

CDAL GUI

The University of Sydney  
Australia

Clinical Data Mining P

CDAL User Interface

General

TOC

SNOMED

Database

gicu

Answers Required (Seperate using commas)

all values of mrn and count of mr

Time Period for Medical Conditions

during the last 1 years

Location for Medical Conditions

gicu

Criteria

Demographic criteria

age > 16

Medical criteria

pf ratio < 300 and pip > 35 or tv expired > 8

Diagnosis Information

Previous diagnosis

Current diagnosis

CDAL Preview

```

USING SNOMED, IN gicu, FIND all values of mrn and count of
mrn FOR PATIENTS, WHOSE age > 16, WITH pf ratio < 300 and
pip > 35 or tv expired > 8, during the last 1 years, IN
gicu

```

Screenshot of a CDAL query: **ARDS SNIFFER**: Find all patients' medical record number (and the number of records retrieved) for patients with age > 16, [AND] arterial blood gas analysis (PaO2 / FiO2) < 300 AND Tidal Volume Peak Pressures (Paw) > 35 OR Delivered tidal volume (Vt) > 8mL IN the GICU (over the last year).  
 Note that: PaO2 / FiO2 = PF Ratio; Paw = PIP; Delivered Vt = Vt Expired

9/1/2008

Enhancing Technologies for Clinical Information Systems

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# Accessible attributes in ICU-CDAL - CareVue

- Chart\_events (total): 786
  - Chart\_events (numeric): 734
  - Chart\_events (categorical): 52
- Medication\_events: 52
- Patient\_events: 6
- Lab\_events: 63
- Group\_events (total): 74
  - Sedation: 8
  - Inotropes: 14
  - Antibiotics: 46
  - Thromboembolic\_prophylaxis: 6
- Total: 981



## Hypothesis Testing

### General

#### Perform

2 means t-test

#### TOC

SNOMED

#### Database

gicu

#### answer Required

MAP

#### Confidence Interval

0.95

#### Test Type

Mean 1 = Mean 2

### Criteria for Patient 1

Demographic Criteria sex = male

Medical Criteria

Time Period during the last 24 hours

Location gicu

### Criteria for Patient 2

Demographic Criteria sex = female

Medical Criteria

Time Period during the last 24 hours

Location gicu



## Hypothesis Testing Results

Two-sample t-test

Null Hypothesis: mean of map for group 1 = mean of map for group 2

Alternate Hypothesis: mean of map for group 1  $\neq$  mean of map for group 2

mean for group 1: 76.6575

sd for group 1: 13.3675

size of group 1: 73

mean for group 2: 82.8824

sd for group 2: 11.2181

size of group 2: 85

degree of freedom: 156

pooled sd for both groups: 12.2571

observed test statistic: -3.1826

p-value: 0.0018

Evidence against the Null Hypothesis in favour with the Alternate Hypothesis.



# 3. Structured Reporting Pathology & Radiology

- Populate a structured report by information extraction from a narrative report
- SRs exist of breast, colorectal, and skin cancer
- Need to verify design against actual reports
- Need to convert historical reports for research
- Adds efficiency and completeness to reports
- Minimises call backs on reports

## 4. Handovers ET

- Generated from an underlying IT infrastructure
- Can be readily varied - regenerated at will
- Particular structure for staff roles
- Extracts from the legacy IS

# Handovers Screenshots

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## User Interface

2 functions:  
generating  
new report  
and retrieving  
existing report

4 templates

3 report type

3 report  
output format

The screenshot shows a web browser window titled "Handovers System - Mozilla Firefox". The address bar shows the URL "http://localhost/cgi-bin/handovericu/handover.py". The page features a header with "The University of Sydney Australia" logo and navigation links: "Getting Started", "Latest Headlines", "CDAL GUI", "Handovers System", and "Inbox". The main content area is titled "Handovers System" and contains two sections. The first section, "Choose Template", has a dropdown menu set to "GICU\_template". Below it, "Choose Report Type" has three radio buttons: "Single with MRN=" (selected), "Single with Bed No.=", and "ALL Current Patients". The "MRN" field contains "9999999". The "Output to" section has three radio buttons: "Browser" (selected), "HtmlFile", and "XMLFile", followed by a "Generate" button. The second section, "Choose Existing Report", has a dropdown menu. Below it, the "Output to" section has the same three radio buttons and a "Generate" button. The browser's status bar at the bottom shows "Done" and the email address "thomas.shadow@gmail.com".

9/1/2008

# Screenshots

21

Handovers  
report for  
general  
purpose

19 attributes  
and 5  
progress  
notes

Around  
4mins to  
generate this  
report

Handover System - Mozilla Firefox

Print... Page Setup... Page: 1 of 1 Scale: 90% Portrait Landscape Close

### Handovers System

05/06/2008-00:05:00

#### General Information

Name: **Testing Person** Age: **18** Sex: **0** MRN: **9999999** Next of Kin: **MCNAUGHT,Adele/Ann** Kin  
Phone: **0488038677** Admit Date: **25/05/2008** Diagnosis: **None** Bed NO.: **Bed 52** Admit Time:  
**Sun May 25 10:43:00 2008** Allergy: **Not Applicable**

#### Vital Signs

Highest Heart Rate: **132.0** Lowest Heart Rate: **116.0** MAP: **98** Temperature: **37.09999847**

#### Signs

Eye Opening: **4 Spontaneously** Leg Movement: **Nil Response**

#### Drugs

Dopamine: **None** Fentanyl: **108.0**

#### Diagnosis Information

Initial Diagnosis and Relevant Background:  
38 yo male with multiple trauma post fall from 8 metres. Angio result - no extravasation form liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis

Assessment:  
1.Unexplained hypotension 2.major abdo/pelvic bleeding excluded 3.looks ok for ortho surgery later today if remaining stable  
1.Unexplained hypotension 2.major abdo/pelvic bleeding excluded 3.looks ok for ortho surgery later today if remaining stable

Diagnosis Test with Result:  
Angio result - no extravasation form liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis

Cardiovascular Examination:  
None

#### Core Plan

Care Plan:  
Conservative treatment of kidney/liver laceration and pelvic fracture - ongoing surgical review. ORIF of bilateral arm fractures.To stay under Trauma team.Usual meds - Aspirin and Coversyl withheld.Conservative treatment of kidney/liver laceration and pelvic fracture - ongoing surgical review. ORIF of bilateral arm fractures.To stay under Trauma team.Usual meds - Aspirin and Coversyl withheld.

9/1/2008

# Screenshots

22

Handovers  
report for  
Doctor usage

14 attributes  
and 5 progress  
notes

Around 3Mins  
and 37 Secs to  
generate this  
report

**Handovers System** 05/06/2008-00:26:02

**General Information**  
Name: **Testing Person** Age: **18** Sex: **0** MRN: **9999999** Diagnosis: **None** Bed NO.: **Bed 52**

**Vital Signs**  
Highest Heart Rate: **132.0** Lowest Heart Rate: **116.0** MAP: **98** BSL: **6.5999999** Heart Rhythm: **Sinus Tachy** Temperature: **37.09999847**

**Signs**  
Eye Opening: **4 Spontaneously** Leg Movement: **Nil Response**

**Diagnosis Information**  
Initial Diagnosis and Relevant Background:  
38 yo male with multiple trauma post fall from 8 metres. Angio result - no extravasation from liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis  
Assessment:  
1. Unexplained hypotension 2. major abdo/pelvic bleeding excluded 3. looks ok for ortho surgery later today if remaining stable  
1. Unexplained hypotension 2. major abdo/pelvic bleeding excluded 3. looks ok for ortho surgery later today if remaining stable  
Diagnosis Test with Result:  
Angio result - no extravasation from liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis  
Cardiovascular Examination:  
None

**Care Plan**  
Care Plan:  
Conservative treatment of kidney/liver laceration and pelvic fracture - ongoing surgical review. ORIF of bilateral arm fractures. To stay under Trauma team. Usual meds - Aspirin and Coversyl withheld. Conservative treatment of kidney/liver laceration and pelvic fracture - ongoing surgical review. ORIF of bilateral arm fractures. To stay under Trauma team. Usual meds - Aspirin and Coversyl withheld.

[Click to Print This Page](#)

9/1/2008

# Screenshots

23

Handovers  
report for  
Nurse Usage

23 attributes  
and 1 progress  
notes

Around 5Mins  
and 38 Secs to  
generate this  
report

The screenshot shows a web browser window titled "Handover System - Mozilla Firefox". The browser's address bar and navigation buttons are visible at the top. The main content area displays a form titled "Handovers System" with a timestamp "05/06/2008-00:28:22" in the top right corner. The form is organized into several sections, each with a purple header:

- General Information**: Contains fields for Name (Testing Person), Age (18), Sex (0), MRN (9999999), Bed NO. (Bed 52), and Admit Time (Sun May 25 10:43:00 2008).
- Vital Signs**: Displays Highest Heart Rate (132.0), Lowest Heart Rate (116.0), MAP (98), and Temperature (37.09999847).
- Signs**: Shows Eye Opening (4 Spontaneously), Leg Movement (Nil Response), Sputum amount (Small), and Stool specimen (None).
- Drugs**: Lists Dopamine (None), Fentanyl (108.0), Atropine (None), Adrenaline (None), infusions (0), and four drains (all None).
- Care Plan**: Contains a detailed text description of the patient's condition and treatment plan, including mentions of kidney/liver laceration, pelvic fracture, and bilateral arm fractures.

Below the Care Plan section, there is a blue link that reads "Click to Print This Page".

9/1/2008

# Screenshots

24

Handovers  
report for  
Pharmacist  
Usage

17 attributes  
and 4 progress  
notes

Around 3mins  
and 9Secs to  
generate this  
report

**Handovers System** 05/06/2008-00:29:25

**General Information**  
Name: **Testing Person** Age: **18** Sex: **0** MRN: **9999999**

**Drugs**  
Dopamine: **None** Fentanyl: **108.0** Atropine: **None** Adrenaline: **None** infusions: **0** Drain #1: **None** Drain #2: **None** Drain #3: **None** Drain #4: **None** Actrapid: **Not Applicable** Dobutamine: **None** Morphine: **3** Ketamine: **None**

**Diagnosis Information**  
Initial Diagnosis and Relevant Background:  
38 yo male with multiple trauma post fall from 8 metres. Angio result - no extravasation form liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis  
Assessment:  
1. Unexplained hypotension 2. major abdo/pelvic bleeding excluded 3. looks ok for ortho surgery later today if remaining stable  
1. Unexplained hypotension 2. major abdo/pelvic bleeding excluded 3. looks ok for ortho surgery later today if remaining stable  
Diagnosis Test with Result:  
Angio result - no extravasation form liver - small renal AV fistula has been coiled - no arterial bleeding in pelvis  
Cardiovascular Examination:  
None

[Click to Print This Page](#)

9/1/2008

# 5. Future Work

## Intensive Care Real-time Audit IS

- Build a computer model for the patient case
- Build a model of the care guidelines
- Fold the two against each other to create an audit



# Front End to Hospital Systems

## Compact Customisable ISs

- Store data to serve a specific function - e.g. WRIS
- Provide rich retrieval functions - CDAL
- Serve an operational purpose
- Can fetch and deliver from other systems
- Add productivity to existing systems
- Tailored and managed to suit a local clinical needs

# Strategic Directions

- Continuous support for handovers for the whole patient journey
- Analytics on all Clinical Info Systems
- Patient tracking from entry to exit
- Automatic conversion of Text to Medical Codes -SNOMED, ICD 10AM, DRGs
- Compute SNOMED subsets from clinical content

# Proposed Developments

- Expand WRIS into a Handovers system
- Make CDAL more portable
- Expand CDAL's Hypothesis testing capacity
- Expand the language processing in both systems
- Continue developing the GCIMS model
- Add workflow to GCIMS
- ICRAIS - Intensive Care Real-time Audit IS
- Compact Nursing ISs using NIC & NOC
- Information Exchange fetching and delivering information from all hospital ISs

# Features of Enhancement Technologies

- None is mission critical, but all give
  - High productivity,
  - Enhanced patient safety and outcomes, and
  - Unheralded access to data especially text
  - Bolt on technologies
  - Removable at any time to allow return to original processes

THE END