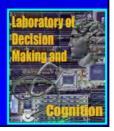# Cognition and Informatics: Knowing, Thinking, and Doing

Vimla L. Patel, PhD, DSc, FRSC
Laboratory of Decision Making and Cognition
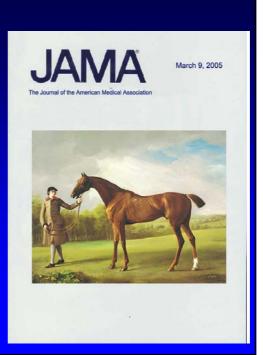**Department of Biomedical Informatics**
Columbia University
New York, NY

APAMI 2006
MIST 2006
Taipei, Taiwan
October 28, 2006

Koppel R, Metlay JP, Cohen A, Abaluck B, Localio AR, Kimmel SE, et al.

Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors

JAMA 2005;293:1197-203.

JAMA
March 9, 2005
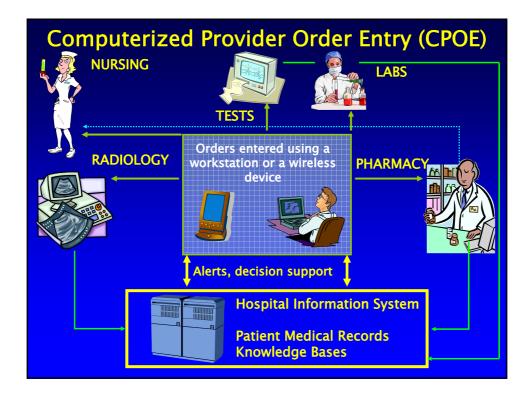The Journal of the American Medical Association

Another Case

Potassium chloride (KCl) ordered as IV injection and as IV fluid additive using Eclipsys CPOE system:

- 85-year-old patient, admitted to the medical ICU with septic shock and respiratory failure
- Patient received 316 mEq KCl over 42 hrs in setting of acute and chronic kidney failure
- High dose delivered due to errors and misperceptions by several care providers
- Compounded errors propagated through the system over three days

Horsky J, Kuperman GJ, Patel VL. Comprehensive analysis of a medication dosing error related to CPOE: A case report. J Am Med Inform Assoc 2005;12:377-382.

Analysis of Failure

- Misconceptions about the relation between IV volume (residents) and time duration (system)

- Confusion regarding latest versus previous laboratory results

- Lack of alerts when serum potassium value reached a dangerous level

- Inadequate user training regarding safe and efficient ordering practices

Computerized Provider Order Entry (CPOE)

NURSING

TESTS

LABS

Orders entered using a workstation or a wireless device

RADIOLOGY

PHARMACY

Alerts, decision support

Hospital Information System

Patient Medical Records Knowledge Bases

Designing for Safety

- **Health information technology (HIT) has reduced the risk of serious injury for hospitalized patients, even though some systems may give rise to hazards of their own**

- **Errors are the product of cognitive activity in human adaptation to complex physical, social and cultural environments**

- **How well the design of HIT complements its intended setting and purpose is critically important for safe and effective performance**

Horsky J, Zhang J, Patel VL. To err is not entirely human: Complex systems and user cognition. J Biomed Inform 2005;38 264-266.

What is Cognitive Science?

Multidisciplinary field incorporating theories and methods from psychology, linguistics, philosophy, anthropology, and computer science in the investigation of cognitive processes in humans and machines
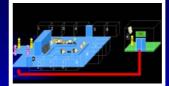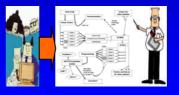
Specific Methods

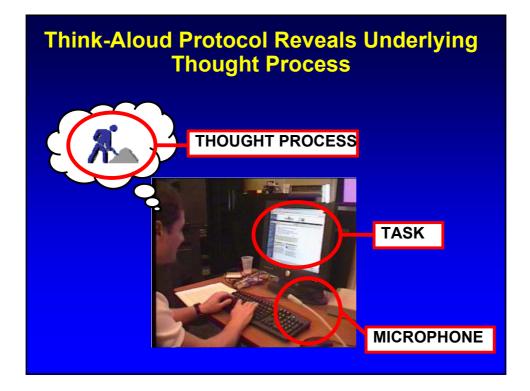**Shadowing of medical team personnel during 'Crucial Periods' pertinent to the individual**

Mapping the activities to the ICU/ER layout and time-stamping each interaction or event

Conducting brief interviews to gain insight on infrastructure, roles, shifts, timings

Obtaining log files of the clinical information systems and attempting correlation with observational data

Think-Aloud Protocol Reveals Underlying Thought Process

THOUGHT PROCESS

TASK

MICROPHONE

Examples of Two Studies in Critical Care

- Clinical workflow for triage decision making in Emergency Room

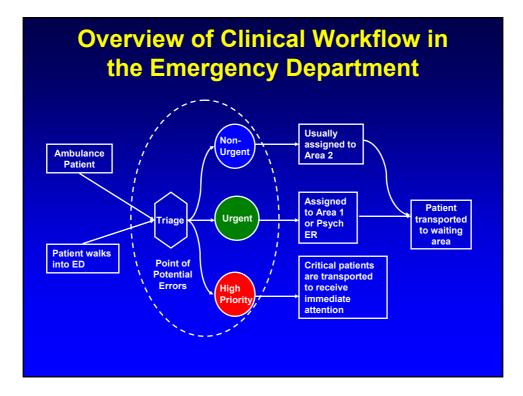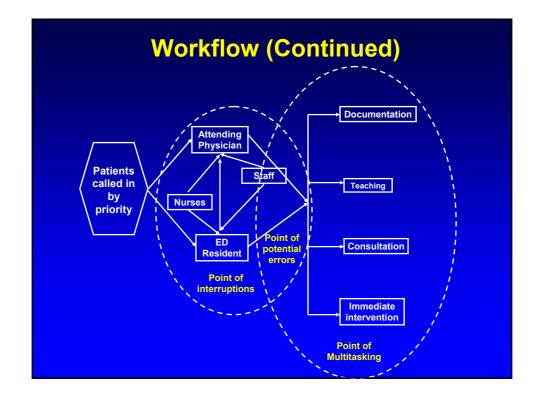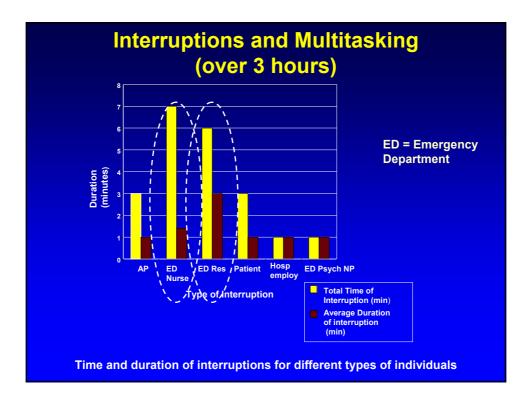- Developing and modeling clinical workflow in Intensive Care Unit

Characterization of Workflow and Triage Decision Making in the Process of Emergency Care

Laxmisan A, Hakimzhada A, Sayan OR, Green RA, Zhang J, Patel VL. The multitasking clinician: Decision-making and cognitive demand during and after team handoffs in emergency care, IJMI (in press).

Horsky J, Gutnik L, Patel VL. Technology for emergency care: Cognitive and workflow considerations, Proceedings of AMIA 2006 (in press).
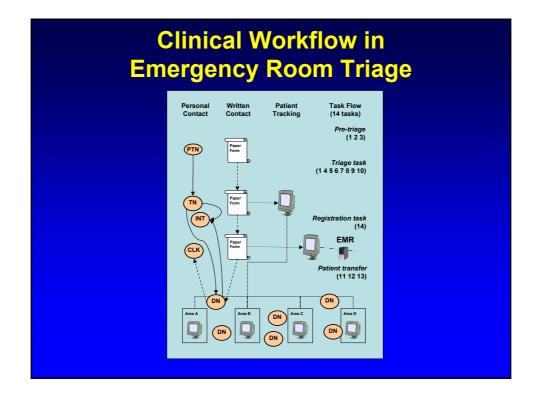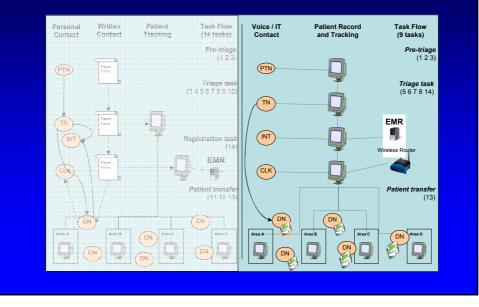
Overview of Clinical Workflow in the Emergency Department

Workflow (Continued)

Interruptions and Multitasking (over 3 hours)

ED = Emergency Department

Time and duration of interruptions for different types of individuals

Pre-Triage Issues in Emergency Dept
(duration 1-2 minutes)

No	Task	Com	Findings - Problems	Recommendations
1	ID patient	Per	Privacy concerns; misspelled names may cause multiple entries in EMR	Separated from waiting room; electronic entry of pt. names
2	Urgency		No decision support; patient history and practice guidelines not accessible	Integrated tracking and EMR systems for immediate recall
3	Patient Destina-tion	Per	Waiting room activity not monitored; no direct communication with fast-track	Pts may be given bracelets; alerts to fast-track personnel
4	Paper form	Wrt	Legibility; single copy for all clinicians	Replace by electronic system

Triage Issues in Emergency Dept
(duration: 12 minutes)

No	Task	Com	Findings - Problems	Recommendations
5	Assess-ment	Per Wrt	Interpreter inaccessible; EMR with visit history unavailable; no guideline access	Communication via PC or intercom; electronic guideline
6	Triage category	Wrt Per	No decision support available; patient longitudinal record/allergies unavailable	EMR may be ready from pre-triage stage for overview
7	Tracking	Elc	Duplication of data from paper; manual updates of state not always accurate	Integrated system with EMR; automatic updates via RFID
8	Workload estimate	Per Elc	Cognitively difficult; requires calls when tracking system is not updated	Tracking can auto-mate this with algo-rithms and updates
9	Patient Desti-nation	Per Elc	Awareness of current overall workload of district nurses required	Tracking system may allocate patients to appropriate area

Clinical Workflow in Emergency Room Triage

Proposed Clinical Workflow in Emergency Room Triage

Summary

- **Failure in interaction among human beings and system agents lead to delays, inefficiencies, and opportunities for error**

- **When information technology is not implemented or not well integrated into workflow, unnecessary tasks are performed and errors are generated**

- **Need to replace inadequate or non-existent technological support of clinicians by specific information and communication technologies that fit the cognitive and workflow demands of the task**

Examples of Two Studies in Critical Care

- **Clinical workflow for triage decision making in Emergency Room**

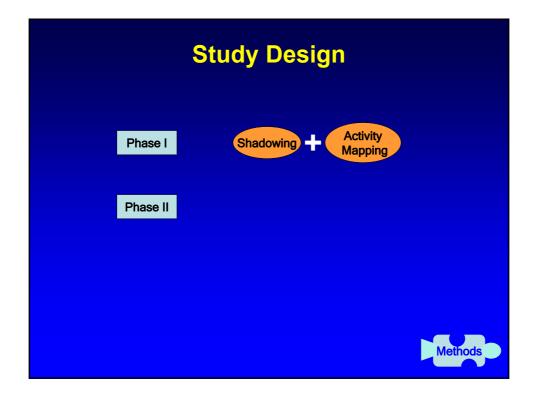- **Developing and modeling clinical workflow in Intensive Care Unit**

Developing
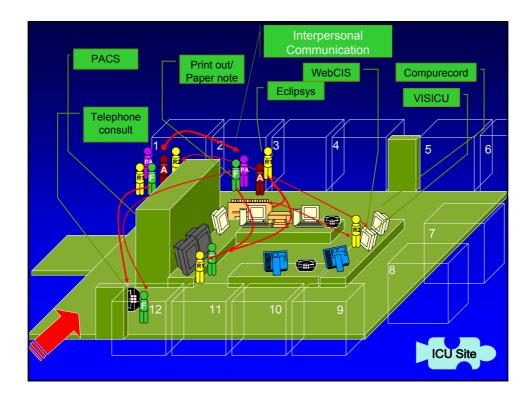# Workflow Model in
Intensive Care Unit

**Maholtra, S., Jordan, D., Shortliffe, E.H., & Patel, V.L.
(2006). Workflow in critical care: Piecing together your
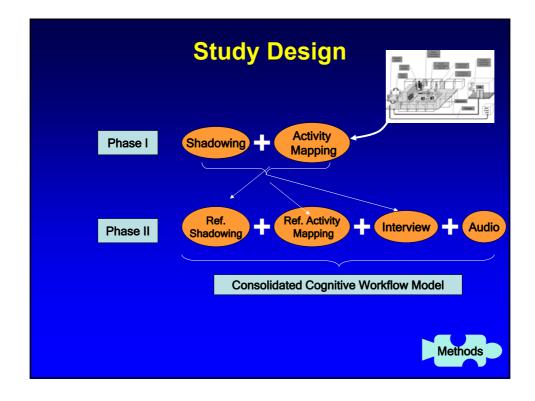own puzzle.** *Journal of Biomedical Informatics* **2006 (in
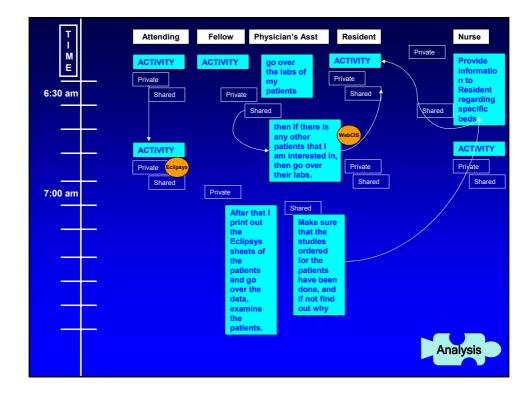press).**

Understanding the Big Picture

**To construct an
overall model of
clinical workflow
and the related
cognitive issues,
we must put it
together piece by
piece**

Study Design

Phase I

Shadowing **+** Activity Mapping

Phase II

Methods

PACS

Print out/ Paper note

Interpersonal Communication

WebCIS

Compurecord

Eclipsys

VISICU

Telephone consult

1 2 3 4 5 6

7

8

12 11 10 9

ICU Site

Workflow Modeling/ Representation

14

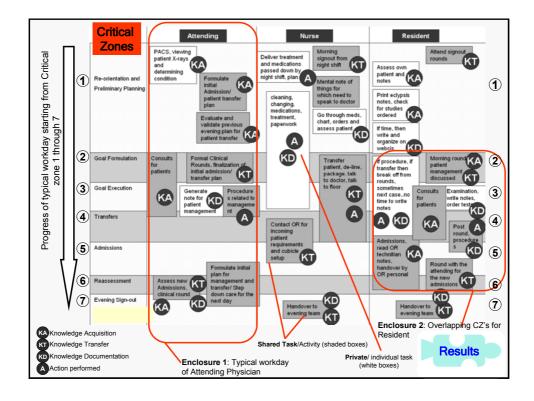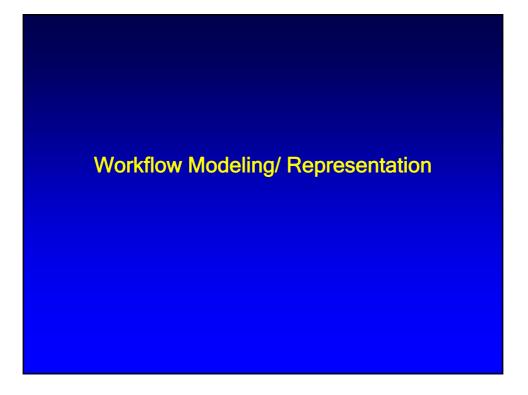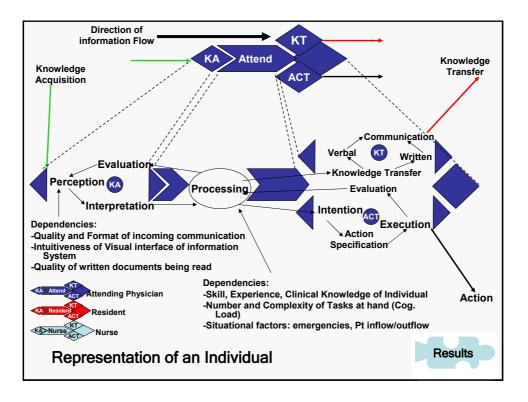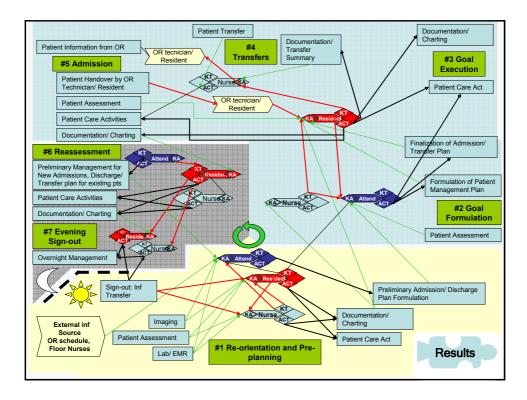Representation of an Individual

Summary

- The representation needs to be configurable and intuitively well matched to the clinical environment
    - Different clinical settings will require customization of the workflow model
- It is important to recognize dependencies
    - Each node in the model (Human or Machine) has dependencies that may alter the outcome
- Better error prediction will require further formal studies of these dependencies

Some Lessons from Cognitive Studies

- Design of HIT must complement its intended setting and purpose to encourage safe and effective performance
- Technology can help to manage errors, but also introduce new opportunities for errors
    - Thus has to be carefully monitored for intended and unintended outcomes
- Technology must support (and thus be sensitive to) how we do our tasks in the clinical environment
    - Exception: when we are doing our task poorly without technology

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More Lessons from Cognitive Studies

- **We need a better understanding of cognitive and situational demands on competent performance of health care professionals when working in teams**

- **We must recognize that acquiring expertise implies developing an ability to adapt flexibly to ever-changing complex situations**

- **Training ("doing") must be supported by adequate education ("knowing" and "thinking") to support safe practices**

**Chapter 4:
Cognitive Science in
Biomedical Informatics
—VL Patel and DR Kaufman—**

Biomedical Informatics Textbook

(3rd edition)

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Edward H. Shortliffe *Editor*
James J. Cimino *Associate Editor*

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Computer Applications in Health Care and Biomedicine

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