VIReC CyberSeminar Series 2007

Using Human Factors Principles in the (Re)Design of Bar Code Medication Administration

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Presentation Overview

Define: Human Factors

Literature Review: Effectiveness & Challenges

BCMA System

Research Studies:

- Study 1 (pre-post obs): “Side effects”
- Study 2 (small, medium, large obs): Workarounds by setting

Translating Findings into Practice

Concluding Remarks

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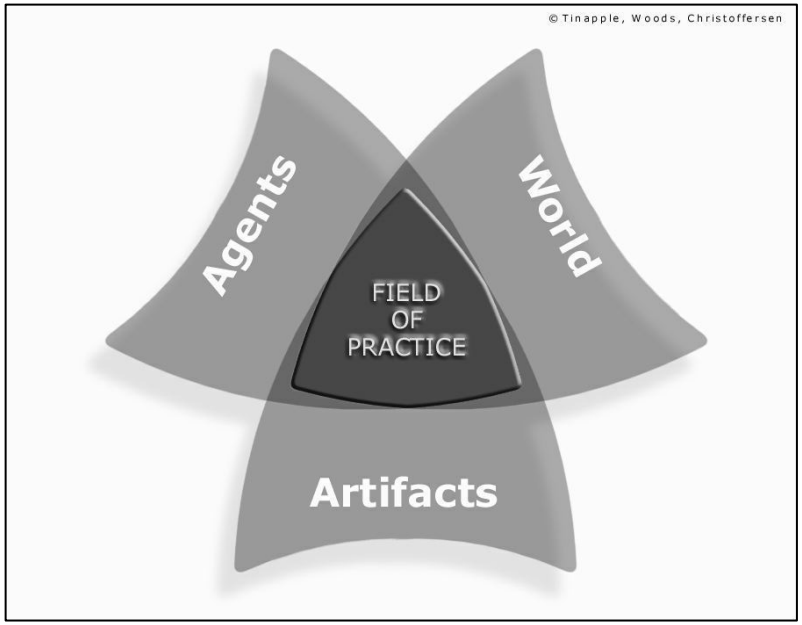
Human Factors:
interdisciplinary human-centered approach to addressing design challenges

Cognitive Systems Engineering (CSE):
engineering a system of human and machine agents performing cognitive tasks in a domain (e.g. planning in anesthesiology)



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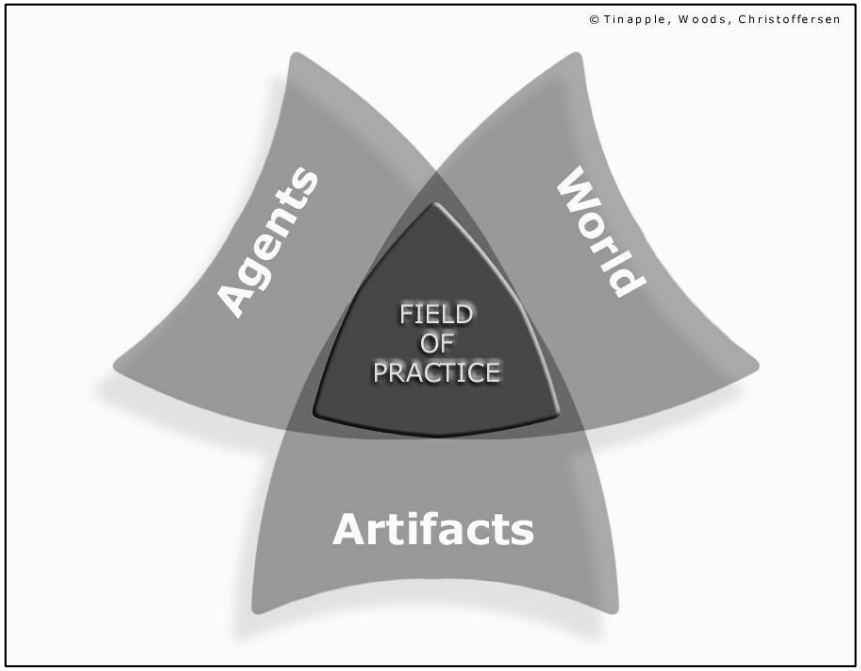
CSE studies cognition…

In challenging:
- situations
- scenarios
- tasks
- domains

With experts:
- expertise
- knowledge
- strategies

Supported by:
- artifacts
- other agents



Cognitive Triad

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Literature Review: Evidence for Effectiveness

Hospital Gamma: Barcode System

- Mixed results on medication error rates
  - With "wrong time" errors:
    - Ward 1: **17%** (pre) vs. **11%** (post)
    - Med/surg: **5%** (pre) vs. **9%** (post)
    - Tele: **6%** (pre) vs. **7%** (post)
  - Without "wrong time" errors:
    - Ward 1: **11%** (pre) vs. **5%** (post)
    - Med/surg: **4%** (pre) vs. **4%** (post)
    - Tele: **6%** (pre) vs. **2%** (post)

~500 doses each

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(Barker, 2004, personal communication)

Literature Review: Evidence for Effectiveness

326 Bed Hospital: CliniCare

- Lower medication error rate:
  - **0.17%** (pre) vs. **0.07%** (post) vs. **0.05%** (one-year post)
- Improved medication records
- Improved scheduling of medications
- Better communication between nursing & pharmacy
- More efficient drug monitoring
- More accurate and timely billing

Challenges:

- Resistance to the change from a manual system
- Steep learning curve for some nurses and physicians
- Some meds not barcoded (unit dose oral, injectables)

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(Puckett, 1995)

Literature Review: Evidence for Effectiveness

University of Wisconsin: BCSS (handheld) Pilot Unit

Pre: 450 medication administrations directly observed compared with physician order in record

Post: 7,013 doses checked by software

9.09% (pre) vs. **1.21%** (post) error rate

- Improper dose; wrong dosage form eliminated
- Omitted dose decreased 92%
- Wrong time decreased 77%
- 3.2% of doses scanned were intercepted
- Self-reported errors decreased 79%
- 42% increase in overall nursing satisfaction

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(Rough, 2005)

Literature Review: Evidence for Effectiveness

University of Wisconsin: BCSS (handheld) Hospital-wide

Challenges:

- Some nursing resistance from additional time
- New sources of error:
  - interface usability
  - miss trends in past doses
  - integration with IV “smart pumps”
- Self-reported errors higher in hospital:
  - IV pump programming
  - pharmacy order entry
  - prescribing near-misses

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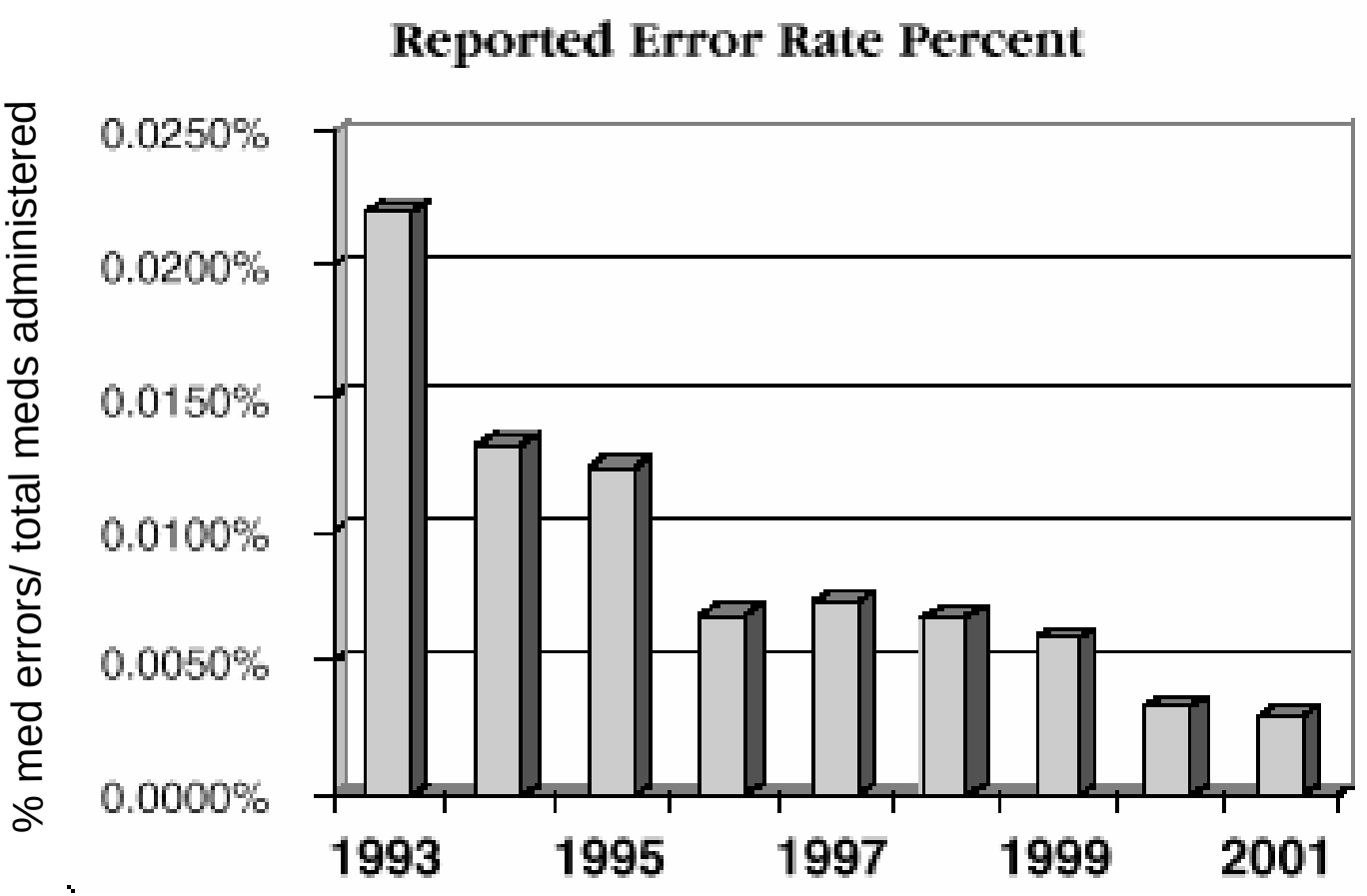
Literature Review: Evidence for Effectiveness

BCMA: Topeka VAMC



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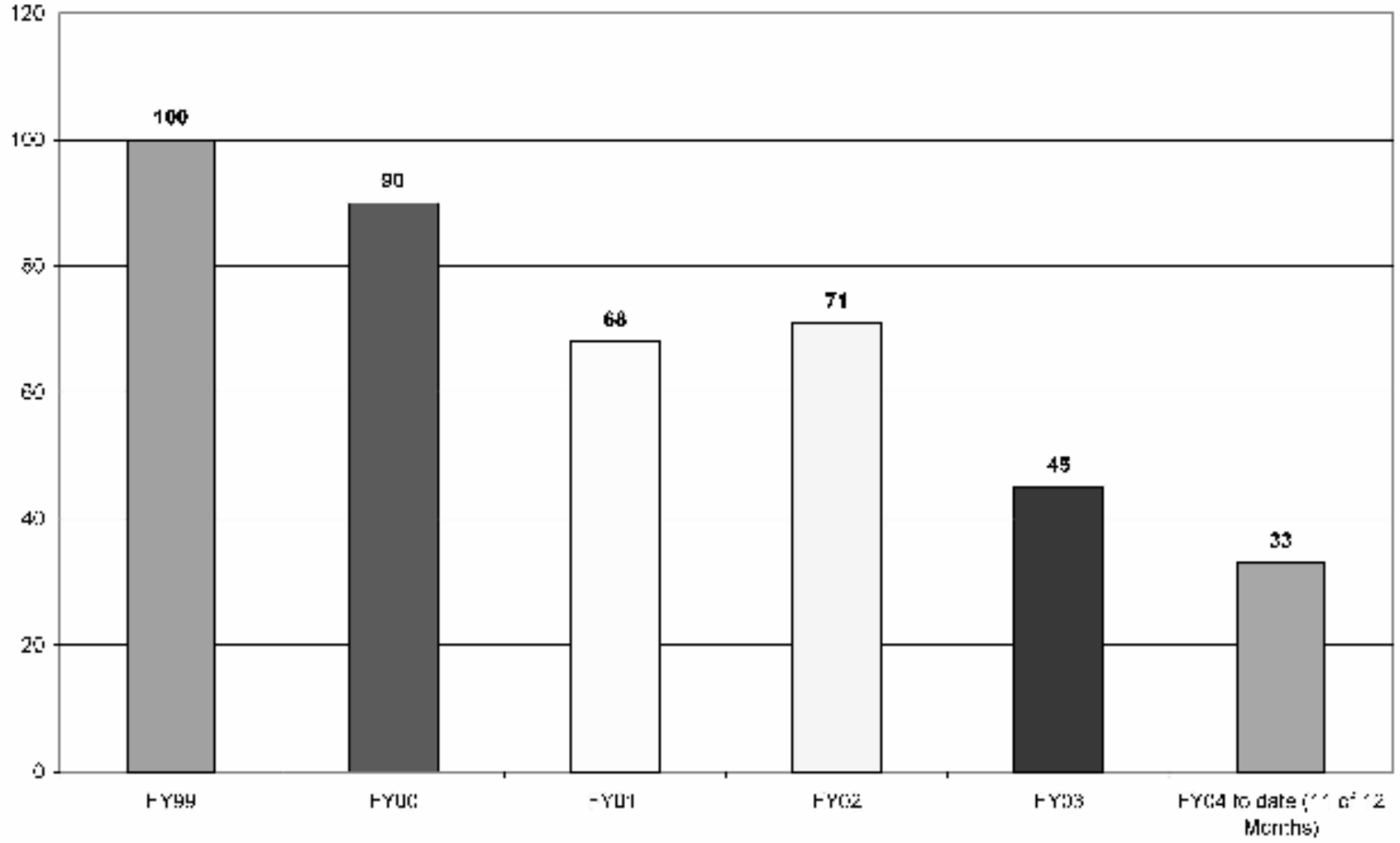
(Johnson, 2002)

Literature Review: Evidence for Effectiveness

BCMA: Martinsburg VAMC

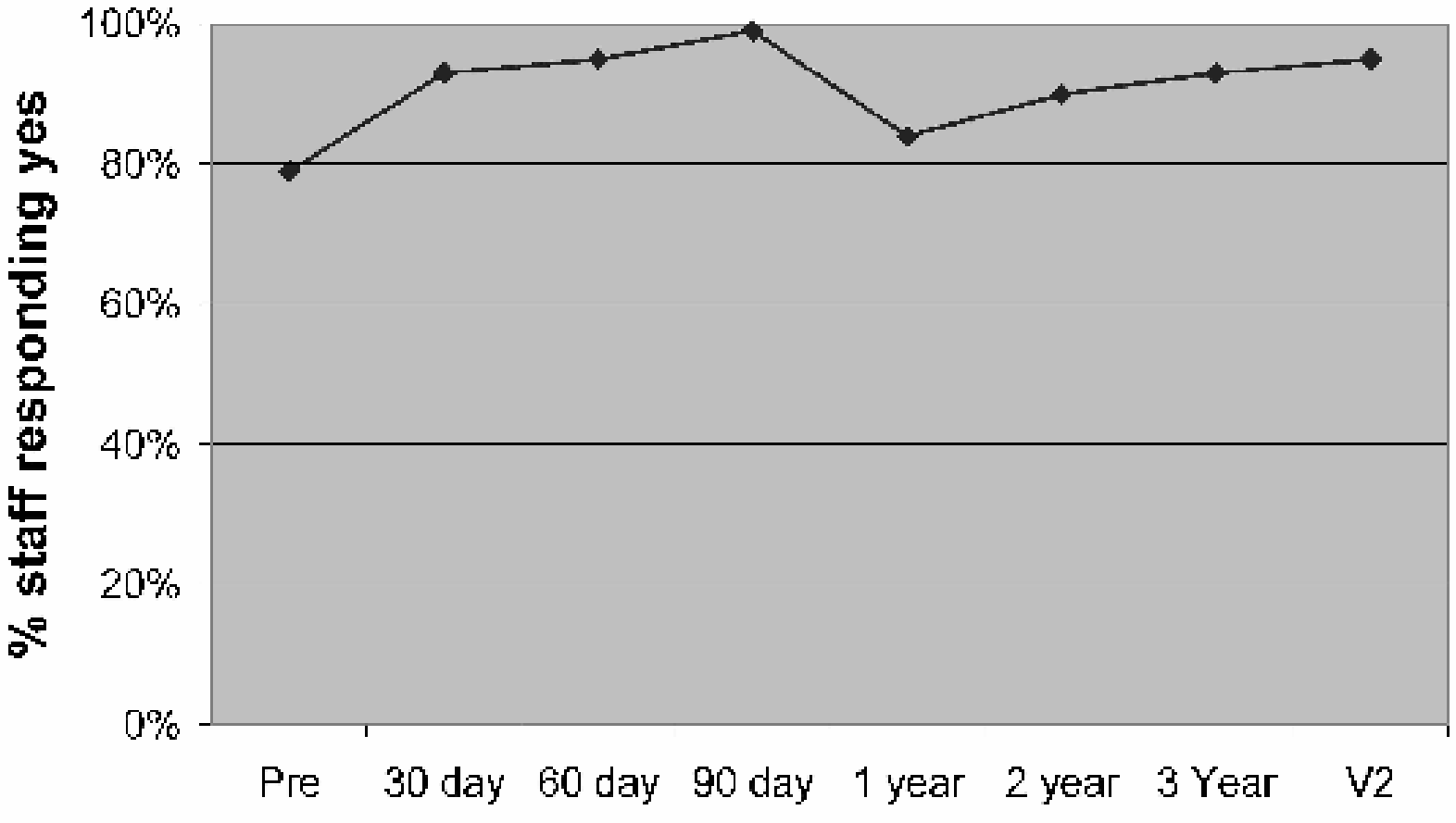


Reported medication errors.

(Coyle & Heinen, 2005)

Literature Review: Evidence for Effectiveness

BCMA: Martinsburg VAMC



Nursing staff perception of BCMA decrease in risk for errors.

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(Coyle & Heinen, 2005)

Literature Review: Evidence for Effectiveness

BCMA: Asheville VAMC 1/2001

"Has BCMA improved patient safety?"

- 19% yes
- 52% partially
- 28% no

Survey:

- N = 54
- 45% response rate
- Convenience sample of nursing staff

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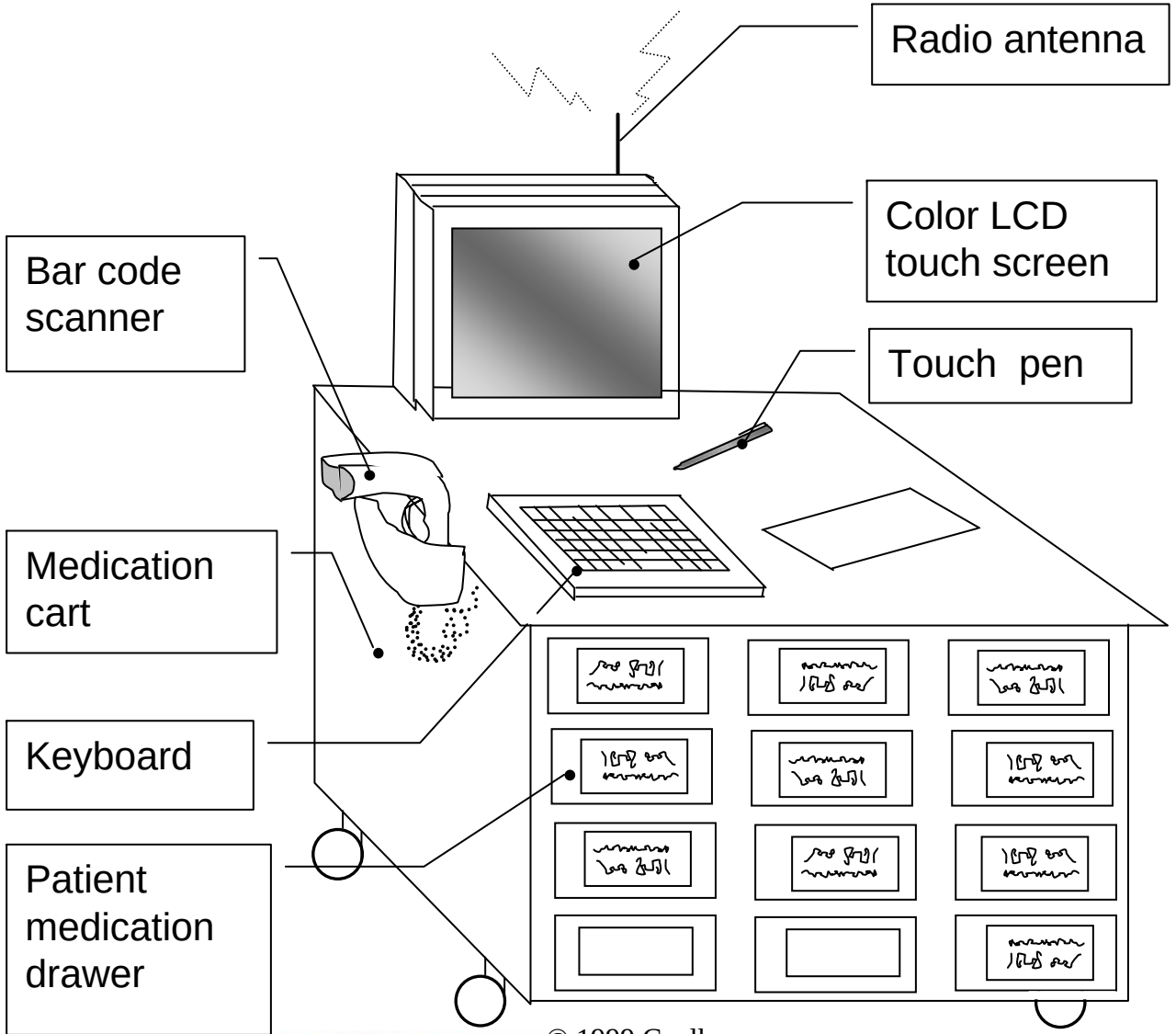
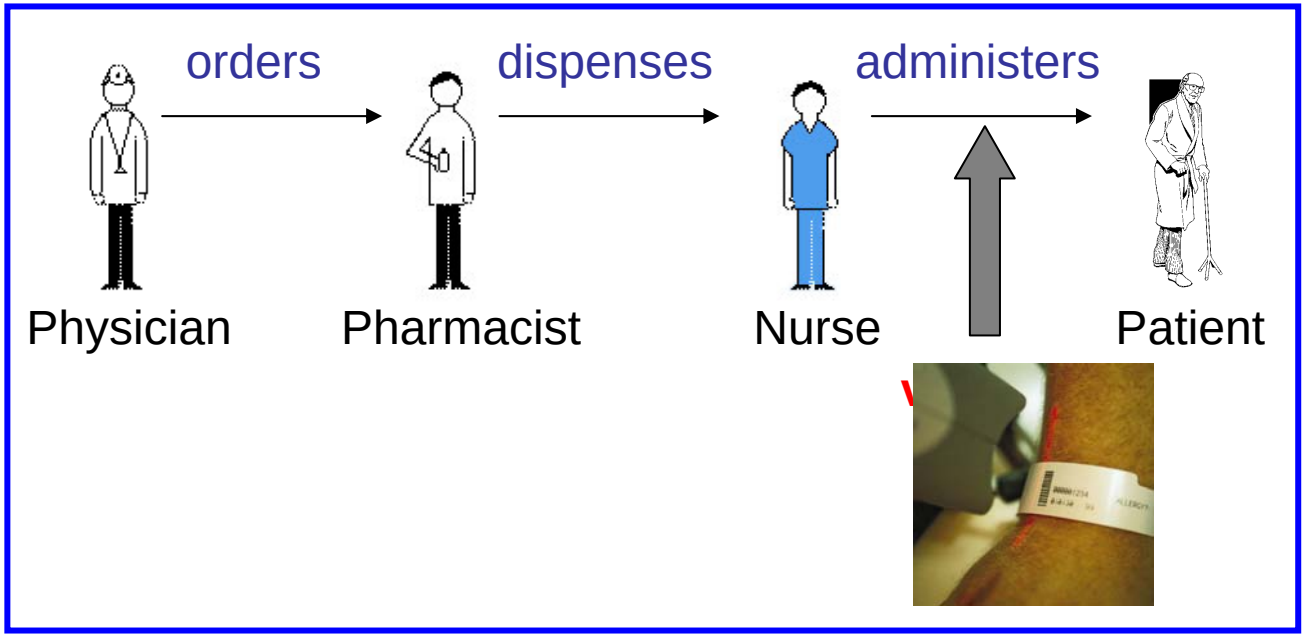
Bar Code Medication Administration (BCMA)



BCMA Objectives

- Enhance accuracy
  - ***drug***
  - ***dose***
  - ***patient***
  - ***route***
  - ***time***



- Reduce time to administer missing medications
- Improve documentation efficiency

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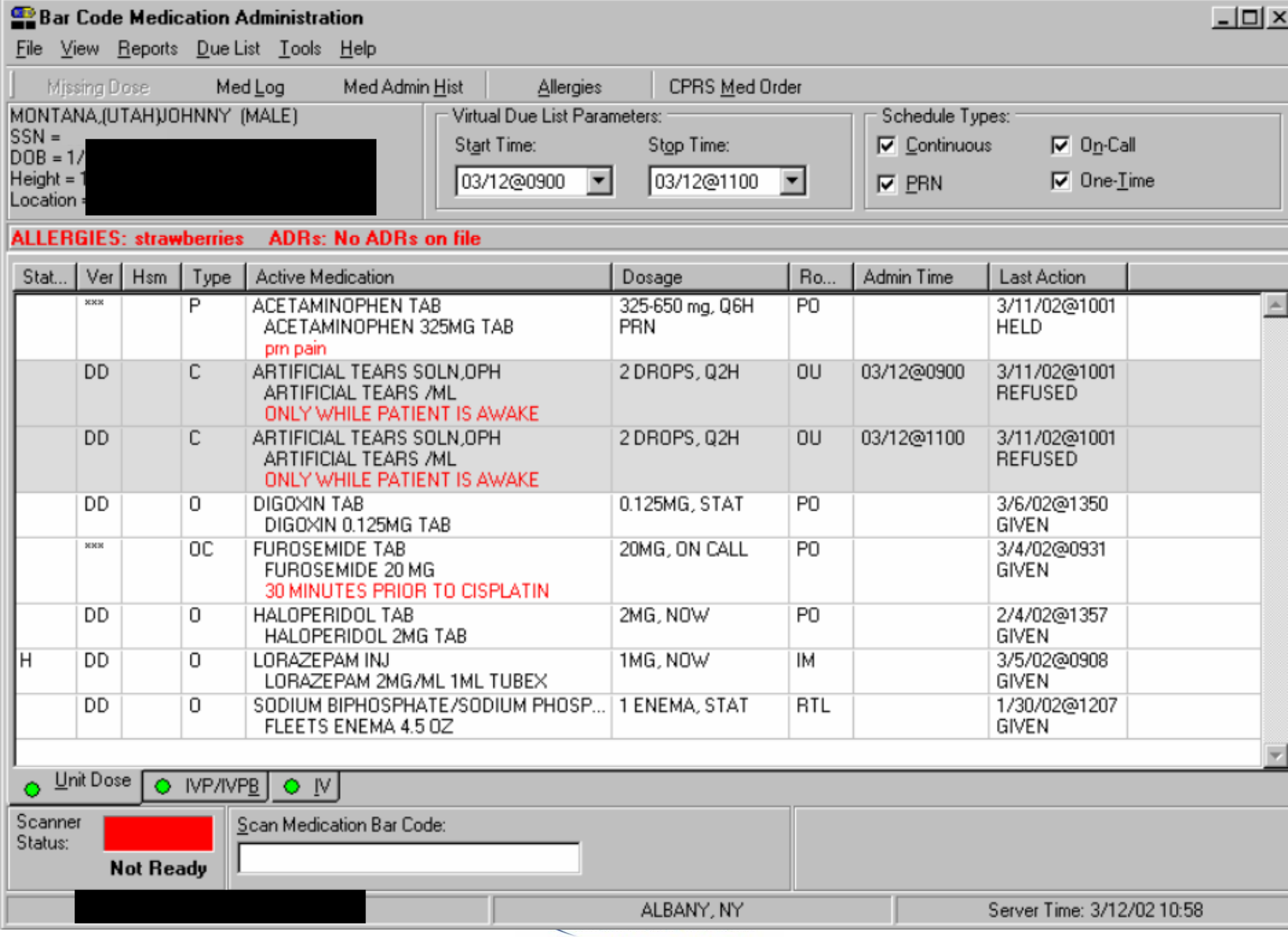
(From training materials)



FICTITIOUS PATIENT RECORD

Study 1 (Observational): Pre-Post Implementation

Objective:

- Identify “side effects” from BCMA implementation

Methods:

- Direct observation of medication administration
- Prior to implementation (21 hrs, 7 nurses, 1 site)
- Following implementation (60 hrs, 26 nurses, 3 sites)
- “Process tracing” protocol analysis
- Mini-case selection (67), classification (12), theme identification (5)

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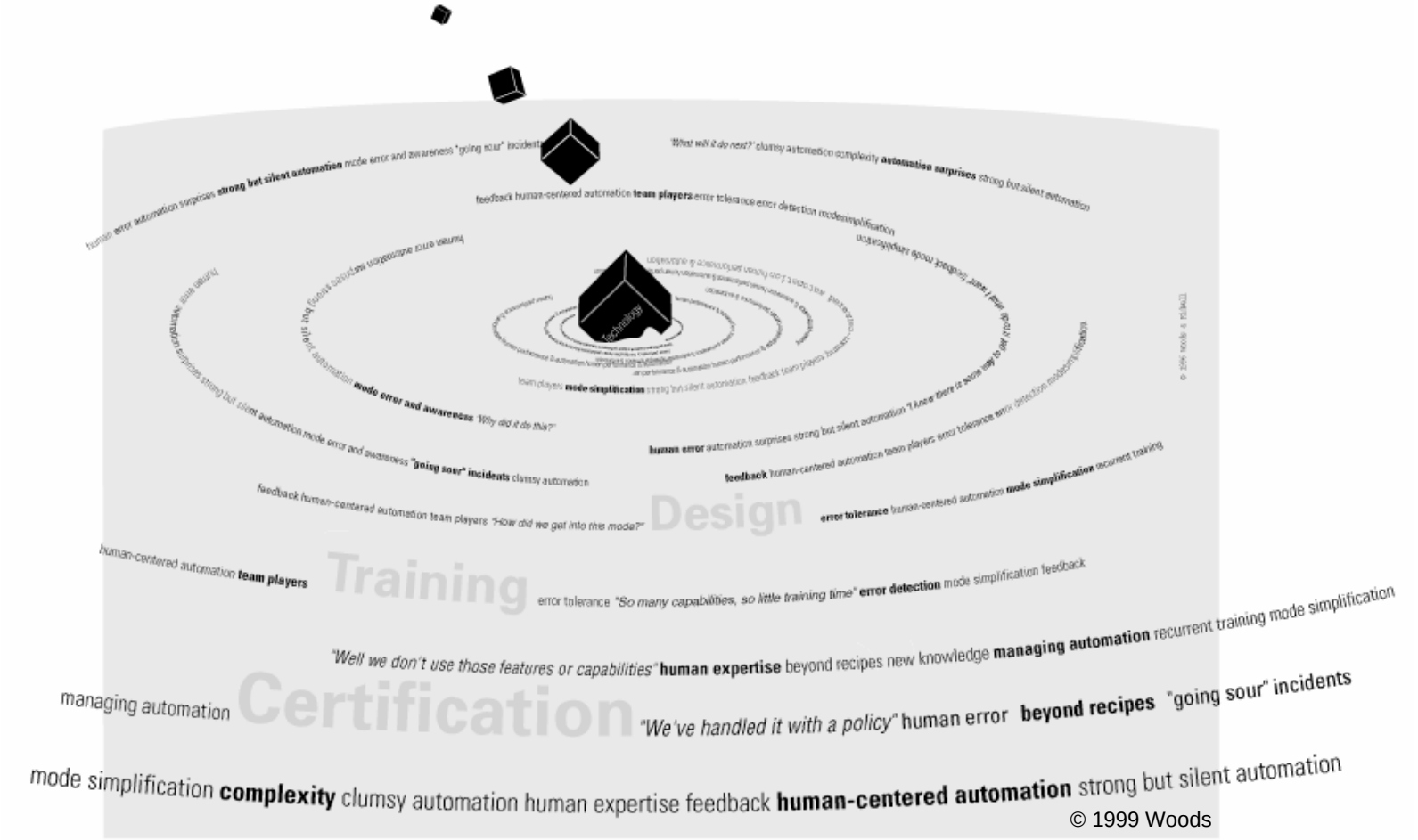
Investigating Side Effects of Change

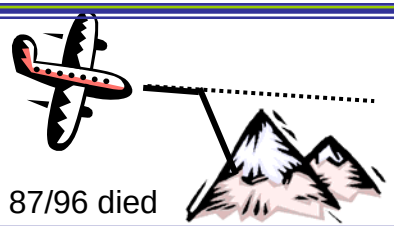
"Adopt a **proactive** approach: **examine new technologies** …for threats to safety and **redesign them** before accidents occur."

IOM report "To err is human" p. 150



Surprises when automation is "strong and silent"

Aviation accidents, lab research



1992 Strasbourg, France; 87/96 died

Degraded **team coordination** when transition from paper to electronic

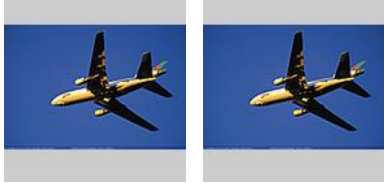
Electronic flight strips in air traffic control

Advisory systems increase **workload** during escalating situations

"Explanation" systems in anesthesiology

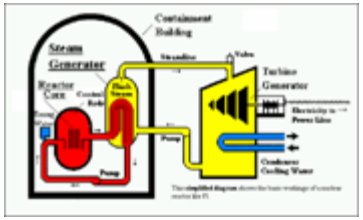
Monitoring raises **priority**

On-time departures in aviation



Automation increases **rigidity** for unanticipated situations

Automated SOPs in nuclear power



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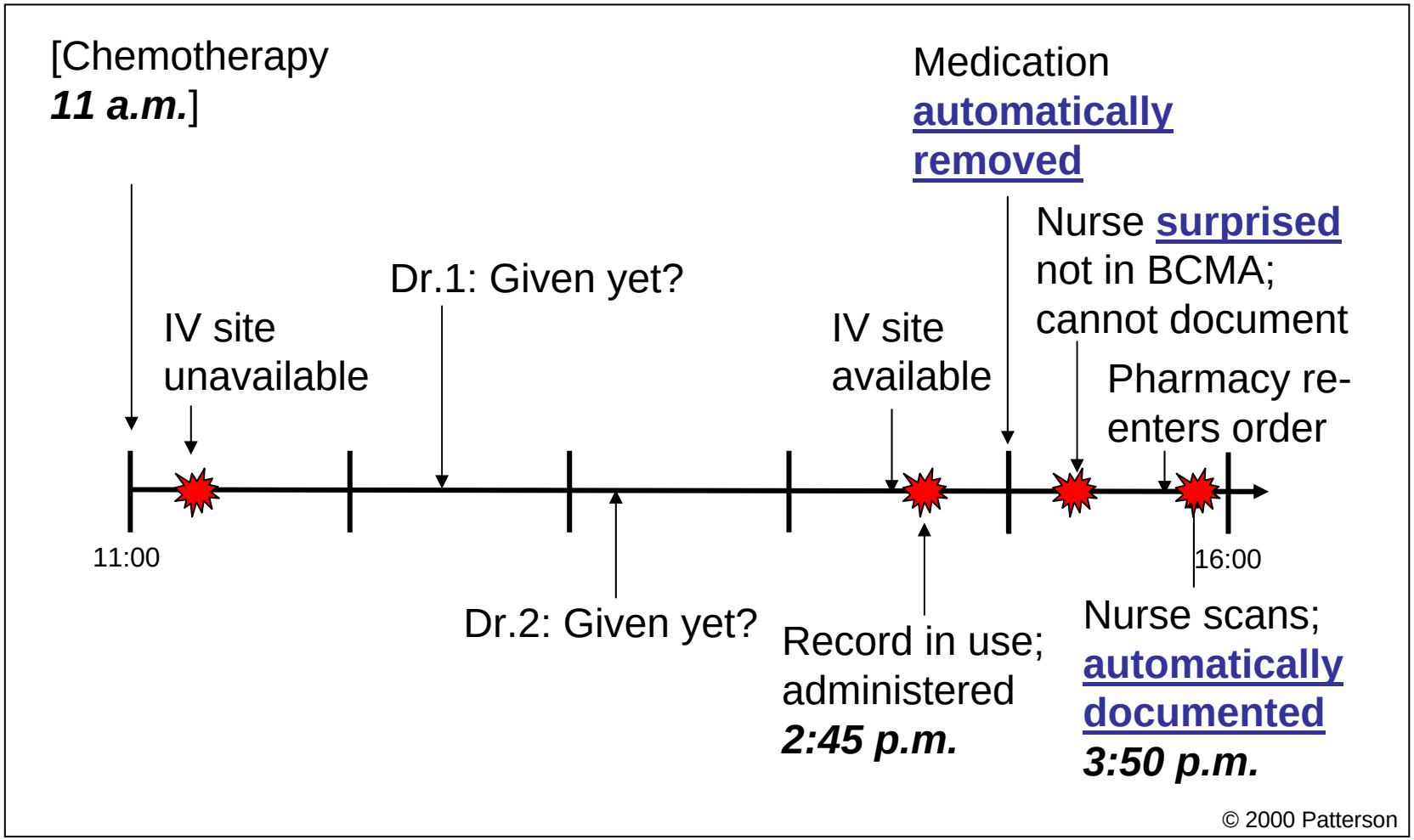
1) "Automation Surprise" with BCMA



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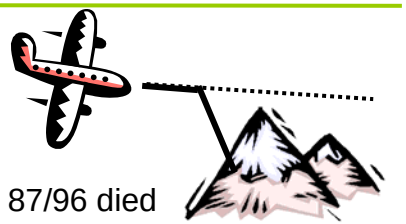
Aviation accidents,
lab research



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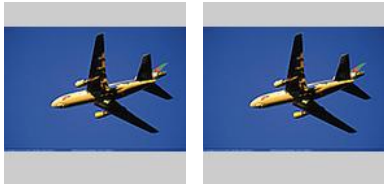

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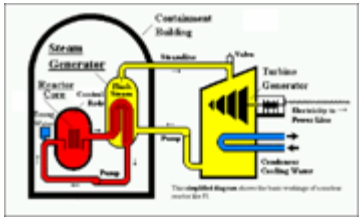

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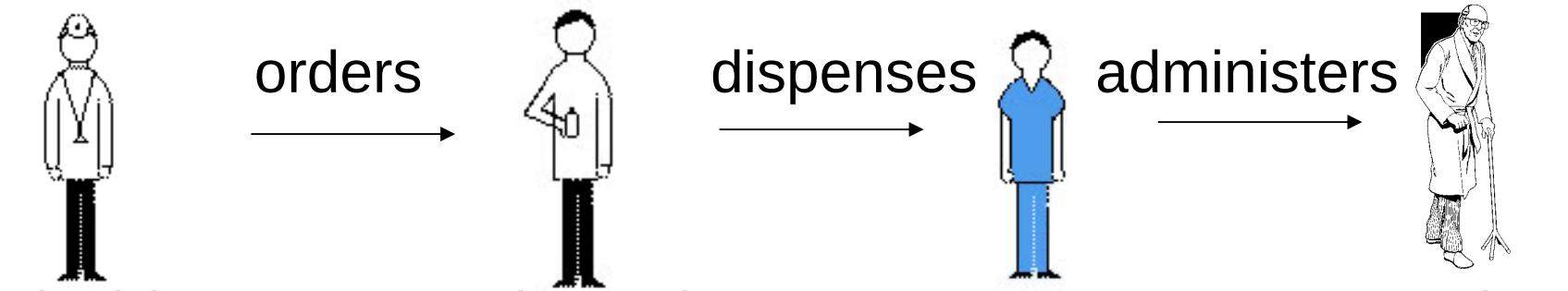
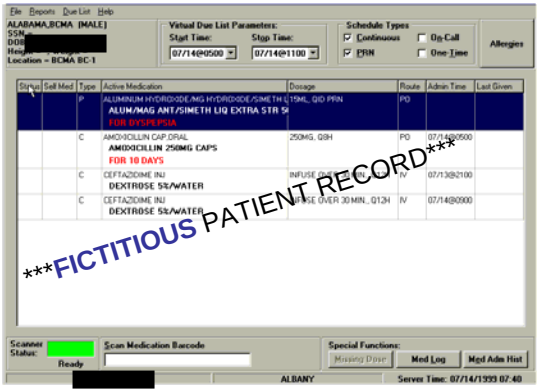
2) Degraded team coordination



Are they ready?

No pending, discontinued information



Do expired orders need to be continued?

Can you co-sign?

Can you order these?

Are you sure?

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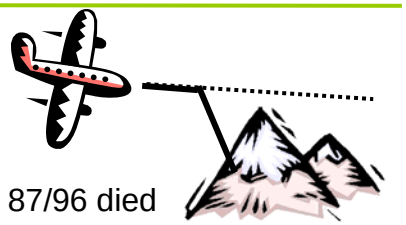
Surprises when automation is "strong and silent"

Aviation accidents, lab research



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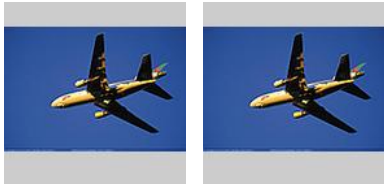

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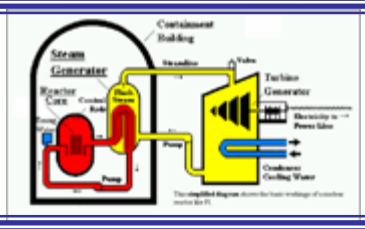

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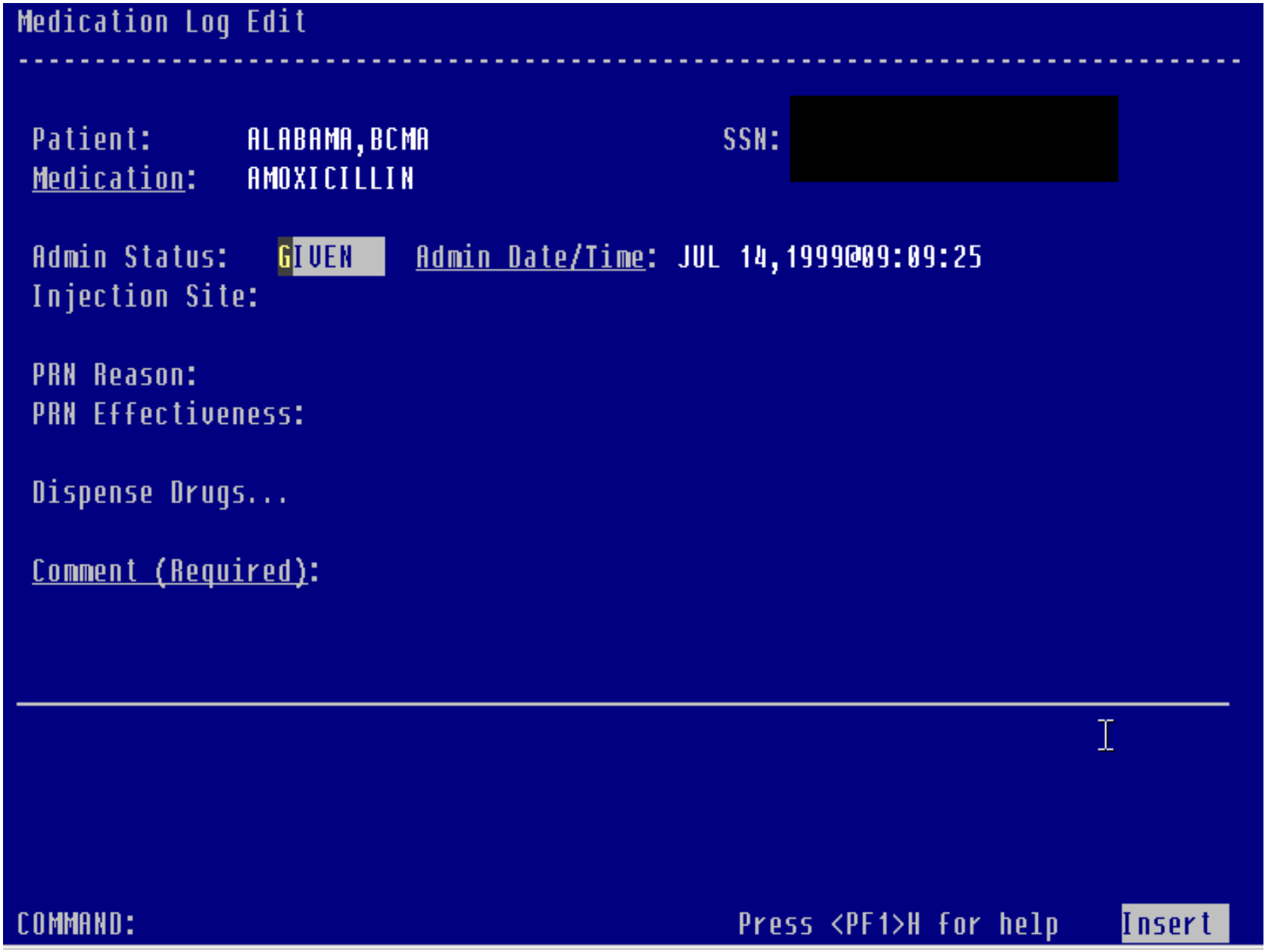
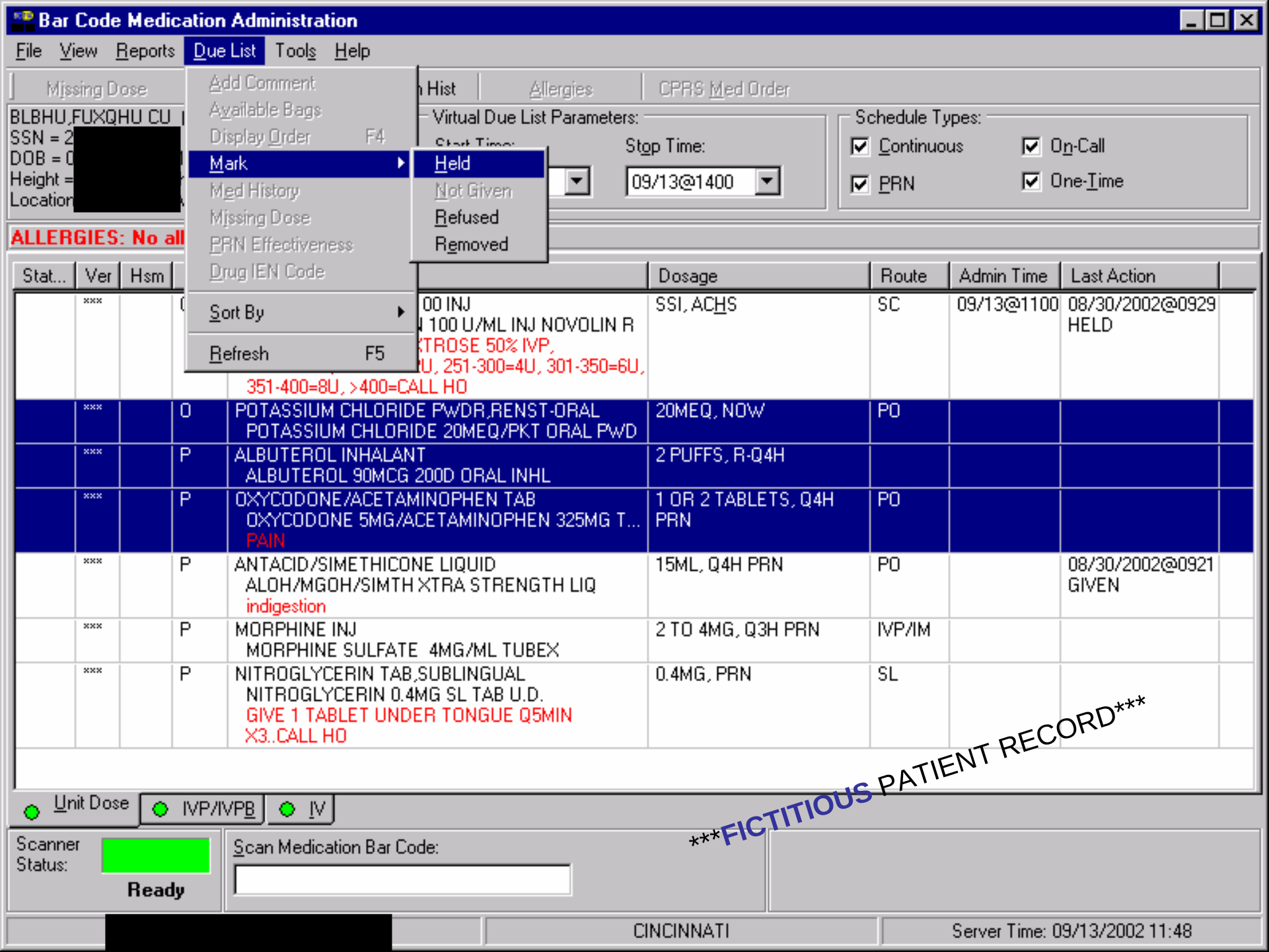
5) Increased rigidity: Refused medication




Bar Code Medication Administration
File View Reports Due List Tools Help
Add Comment
Available Bags
Display Order F4
Mark
Med History
Missing Dose
PRN Effectiveness
Drug IEN Code
Sort By
Refresh F5
Held
Not Given
Refused
Removed
Missing Dose
Allergies
CPRS Med Order
BLBHU,FUXQHU CU
SSN = 2
DOB = 0
Height =
Location
Virtual Due List Parameters:
Stop Time:
09/13@1400
Schedule Types:
Continuous
On-Call
PRN
One-Time
ALLERGIES: No all
Stat... Ver Hsm
Dosage Route Admin Time Last Action
SSI, ACHS SC 09/13@1100 08/30/2002@0929 HELD
351-400=8U, >400=CALL HO
POTASSIUM CHLORIDE PWDR,RENST-ORAL
POTASSIUM CHLORIDE 20MEQ/PKT ORAL PWD
20MEQ, NOW PO
ALBUTEROL INHALANT
ALBUTEROL 90MCG 200D ORAL INHL
2 PUFFS, R-Q4H
OXYCODONE/ACETAMINOPHEN TAB
OXYCODONE 5MG/ACETAMINOPHEN 325MG T...
PAIN
1 OR 2 TABLETS, Q4H PRN PO
ANTACID/SIMETHICONE LIQUID
ALOH/MGOH/SIMTH XTRA STRENGTH LIQ
indigestion
15ML, Q4H PRN PO 08/30/2002@0921 GIVEN
MORPHINE INJ
MORPHINE SULFATE 4MG/ML TUBEX
2 TO 4MG, Q3H PRN IVP/IM
NITROGLYCERIN TAB,SUBLINGUAL
NITROGLYCERIN 0.4MG SL TAB U.D.
GIVE 1 TABLET UNDER TONGUE Q5MIN X3..CALL HO
0.4MG, PRN SL
Unit Dose
IVP/IVPB
IV
Scanner Status:
Ready
Scan Medication Bar Code:
FICTITIOUS PATIENT RECORD
CINCINNATI
Server Time: 09/13/2002 11:48

Study 1: Limitations

- Improvements made since observations (2000-2001)
- Missed side effects since data collection and analysis shaped by frameworks
- Unclear if findings generalize to other hospitals, software, devices with barcode input
- Not examined:
  - Positive “side effects”
  - Effectiveness in reducing med errors
  - Time spent administering medications
  - Impact on others (pharmacists, physicians, respiratory therapists, nursing aides, patients)

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Study 2 (Observational): Background

- Medication errors most common cause of hospital AEs
  - Rate: 3.7% (chart review) to 17.7% (observations)
  - Cost: $1.33/$1 for medication
  - When: 38% during nursing administration
- Long-term care:
  - Larger patient:nurse ratio
  - More medications (per patient, per “medication pass”)
  - Longer patient stays

Study 2 Methods

Objective:

- ID BCMA workarounds in acute and long-term care

Prospective ethnographic study:

- Direct observation of medication administration; opportunistic interviews
- Setting: 1 small, 1 medium, 1 large hospital
- Data collection: Field notes, BCMA data
- Data analysis:
  - Workarounds from “process tracing” protocols
  - Barriers to desired use from interviews

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No. Observations by Facility

	Small Hospital	Medium Hospital	Large Hospital	Total
Acute Care				
Nurses	5	5	5	15
Medication passes	6	6	5	17
Hours	13	9	20	42
Long-Term Care				
Nurses	4	6	3	13
Medication passes	5	6	4	15
Hours	11	15	11	37
Total nurses	9	11	8	28
Total medication passes	11	12	9	32
Total hours	24	24	31	79

Patient Identification Strategies

	Small Hospital	Medium Hospital	Large Hospital	Total Nurses
Acute Care				
Scans armband	4	1	3	8
Surrogate armband	0	0	0	0
Types SSN	1	4	2	7
Proportion scanning	4/5 (80%)	1/5 (20%)	3/5 (60%)	8/15 (53%)
Long-Term Care				
Scans armband	0	1	0	1
Surrogate armband	4	0	1	5
Types SSN	0	5	2	7
Proportion scanning	0/4 (0%)	1/6 (17%)	0/3 (0%)	1/13 (8%)

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p=0.016, Fisher's exact test

Barriers to Scanning Wristbands

- Medium hospital: tethered scanners
- Carts stationary in long-term care
  - Larger carts (more medications)
  - More battery replacements (longer med passes)
- Longer patient stays in long-term care
  - Dirty, twisted, torn, missing, wet wristbands
  - Nurses more familiar with patients

“Best Practice” Recommendations

Topic	Best Practice Recommendation
Implementation/ continuous improvement	1. Standing interdisciplinary committee
Training	2. Train all nurses; cross-train others
Troubleshooting	3. Communicate known problems 4. Contact information for types of problems
Contingency planning	5. No “double documentation” as a backup 6. Schedule downtimes to minimize disruptions
Equipment maintenance	7. Swap broken equipment with backup unit 8. Procedures to clean equipment
Medication administration	9. Scan barcoded wristbands and medications 10. Caregiver documents at time of administration 11. Verify allergy information displayed in BCMA 12. Use printed worksheet as overview 13. Print “missed meds report” once a shift 14. Alert nurses to new STAT orders
Wristband maintenance	15. Periodic replacement of wristbands

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Study 2: Limitations

- Improvements made since observations (2000-2002)
- Hawthorne effect: participants less likely to use workarounds
- Facilities, wards, nurses convenience sample
- Small sample size relative to target population
- Unclear if findings generalize to other hospitals, software, devices w/barcodes

Study 2: Summary

- In long-term care vs acute care:
  - Less scanning of wristbands to identify patients
  - More “pre-pouring” as administration strategy
  - Less detailed reports to detect errors
- “Workarounds” (in both settings)
  - Reduce effectiveness
  - Reduce accuracy of documentation
- Redesign and organizational changes recommended (***not*** sanctioning, training)

Paper Reports Used by Nurses

	Small Hospital	Medium Hospital	Large Hospital	Total Nurses
Acute Care Reports				
Ward Admin	0	0	0	0
End of Shift	0	2	3	5
Medication list	5	2	1	8
Personal	0	1	0	1
Nothing	0	0	0	0
Total	5	5	4	14
Long-Term Care Reports				
Ward Admin	3	6	3	12
End of Shift	0	0	0	0
Medication list	1	0	0	1
Personal	0	0	0	0
Nothing	0	0	0	0
Total	4	6	3	13

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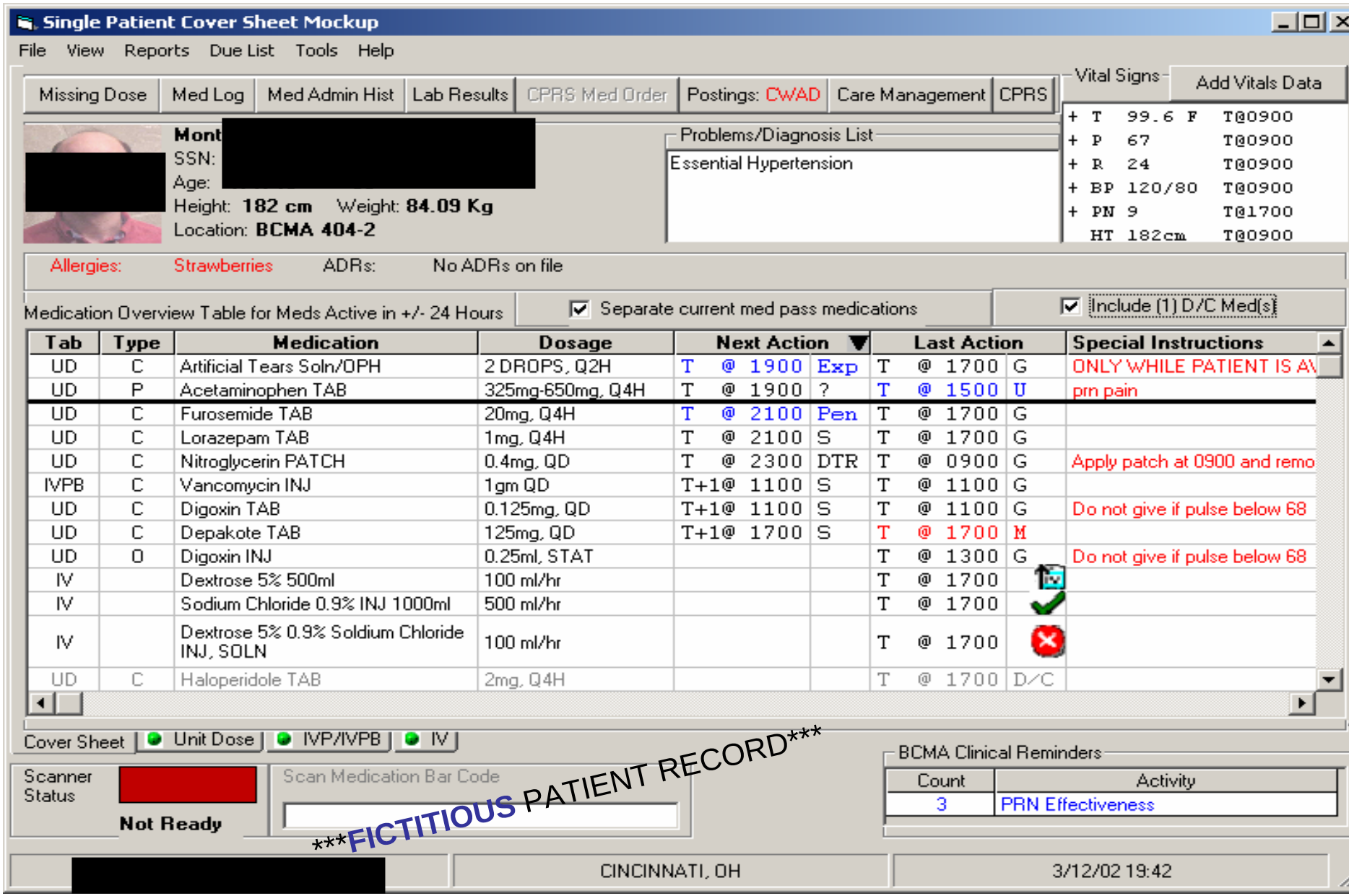
$p<0.0001$, Fisher's exact test

Report Information

- *Long-Term Care:* Ward Administration
  - Number of medications/patient/hr

- *Acute Care:* End of Shift, Medication List
  - Medication name
  - Dose
  - Route
  - Special instructions (physician, pharmacist)

Cover Sheet Overview Display (Prototype)



Translating Findings into Practice

15 “best practices”

- Dissemination via National BCMA Joint Program Office, BCMA workgroup
- Joint Commission Journal

Prioritized design modifications

- V1.0: 5/10 high priority, 2/9 medium priority, and 1/8 low priority implemented
- V2.0: 4/5 participants missed all IV medications for at least 1/6 fake patients
- V2.0 redesign: 1/4 participants missed one IV medication for 1/6 fake patients

“Cover sheet” enhancement

- Concept storyboard designed collaboratively with developers

Beyond VHA

- Press releases for key publications (~70 requests for reprints)
- Postings on NPSF patient safety listserv (~1500 recipients)
- FDA cited research as evidence for need for flexibility
- Consultations (hospitals, device companies, “best practice” groups, researchers)

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Concluding Remarks

- Very high failure rates for software internationally
- Human factors experts (partnering with medical experts) can radically improve usefulness, usability, adoption rates
- Need for “bridge” funding for HF experts:
  - Steep learning curve if no healthcare experience
  - Significant ramp-up time before competitive as PI
  - Structural challenges pervasive in obtaining funding
    - 1 grant submission per round, expectation that PI is 10-20% FTE, no equivalent for “clinical funding,” methods foreign to reviewers, recent MREP and PSCI funding issues, traditional tenure initiating units do not have 5/8 appointments, research in other domains easier to fund and conduct
  - Translating into practice requires “infrastructure” funds
  - “Good citizen” expectations high
  - Long tails post-award to translate research into practice

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