Adherence Engineering to Reduce Central Line Associated Bloodstream Infections

Frank A. Drews
University of Utah
IDEAS, VAMC Salt Lake City

Hosted by
Dr. Hugo Sax
University Hospital of Zurich, Switzerland

"Human error in medicine, and the adverse events which may follow, are problems of psychology and engineering not of medicine." John Senders, 1993

That field involving research into human psychological, social, physical and biological characteristics, maintaining the information obtained from that research, and working to apply that information with respect to the design, operation or use of products or systems for optimizing human performance, health, safety and / or habitability.

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Human Factors

- Accidents

When multi-tasking breaks down.

Human Error

- Human Error
  - 60-90% of causes in major accidents / incidents in complex systems are due to human error

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Human Factors

- Accidents

Field of Human Factors

- Role of human factors
  - Breakdown in interaction between humans and system
    - Usually the systems work well
  - Provides diagnosis and solution

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Field of Human Factors

– Goals of Human Factors
  • Reduce error
  • Increase productivity
  • Enhance safety
  • Enhance comfort

Field of Human Factors

– Applying Human Factors
  • Steps in the cycle of human factors
    – Problem
    – Analyze the causes
      » Task analysis
      » Statistical analysis
      » Incident and accident analysis
    – Identify the problems and deficiencies in the human-system interaction
Field of Human Factors

- Steps in the cycle of human factors
  - Implementation
    » Task design (no manual lifting)
    » Equipment design (readable labels)
    » Training (physical and mental skills)
    » Environmental design (lighting, noise, organizational climate)
    » Selection (no colorblind pilots)
  - Evaluation

Diagram:

1. Analysis
2. Implementation
3. Evaluation
4. Identification
5. Solution
6. Problem
Field of Human Factors

• Successful applications of Human Factors
  – Aviation
  – Nuclear Power Plants

Background

• Two types of performance breakdowns
  – Human Error
    • Planning, memory, and execution
    • Cognitive under-specification
  – Violations
    • Whenever there are standards, rules, regulations
    • People experience them as cumbersome
    • People invent “better” ways of performing a task
    • Cognitive over-specification
Contributors to performance breakdowns

- Violations
  - Inconvenient to comply, easy to violate, low likelihood of detection ($p=0.42$; range=0.28-0.58)
  - Compliance fairly important, but chance of detection of violation low ($p=0.38$; range=0.21-0.55)
  - Socially unacceptable, chance of detection high, chance of bad outcome high ($p=0.0001$; range=0.00002-0.003)
Background

– Conditions that increase the likelihood of violations
  • Low likelihood of detection
  • Inconvenience
  • Authority to violate
  • No disapproving authority figure present
  • Male

Background

• When we want people to adhere to best practices, we need to control performance
  – Internal control
    • Training, certification, etc.
  – External control
    • Standardization, protocols, evaluation of performance
Adherence Engineering

- Adherence Engineering
  - Conceptual framework to reduce violations and increase protocol adherence
  - Complementary approach to others (e.g., training)
  - Seven guiding principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adherence</td>
<td>Make use effective. Rules to ensure viability of the protocol.</td>
</tr>
<tr>
<td>Task barriers</td>
<td>Provide a structured and stepwise task sequence. Separation of tasks to allow multiple actions that differ at different locations and at different times.</td>
</tr>
<tr>
<td>Nursing</td>
<td>Support adherence by suggesting assistance in identifying symbols. Providing level goals in pockets, providing peer-to-peer feedback during training.</td>
</tr>
<tr>
<td>Teamwork</td>
<td>Provide a clear and defined role of each person. Selection of a person for a specific task makes them responsible for that task (e.g., a specific color or a specific role).</td>
</tr>
<tr>
<td>Feedback</td>
<td>Provide easy monitoring and assessment of clinical performance. Patches are a good way to prevent discrepancies.</td>
</tr>
<tr>
<td>Motivating patient effort</td>
<td>Support the patient's role by reducing the required effort.CHOOSING THE RIGHT DRESS, YOUR BODY AS A SHAPING TOOL</td>
</tr>
<tr>
<td>Maintaining physical effort</td>
<td>Make adherence sustainable. Breaks in skills require measurements (e.g., physical activity: distance walked, steps taken).</td>
</tr>
</tbody>
</table>

---

Adherence Engineering

- Principles
  - Object affordance (Norman, 1988)
    - Create object affordance (a quality of an object/environment allows the performance of an action).
Adherence Engineering

— Principles
  • Task intrinsic guidance (Drews et al., 2005)
    — Provide structure
    — Provide preview
  • Nudging (Thaler & Sunstein, 2008)
    — Provide optimized choices
    — Opt-in vs opt-out
  • Smart Defaults
    — Eliminating, minimizing number of choices
    — People are easily overwhelmed with too many choices

Adherence Engineering

— Principles
  • Provide feedback (Norman, 1988; Durso & Drews, 2010)
    — Create visibility (e.g., catheter hub swabbing vs capping)
    — Feedback about effectiveness of performance and protocol adherence
    — Permits adherence audits
  • Reduce cognitive effort required for task performance (Fiske & Taylor 1984; Tversky & Kahneman, 1974)
    — People are cognitive misers – they try to minimize cognitive effort whenever possible
    — Extensive planning requirements make it more likely that people do not adhere with procedure
    — But: Yerkes-Dodson law
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

Adherence Engineering

– Principles
  • Reduce physical effort required during task performance
    – People do not like to engage in physically effortful activities
    – We try to minimize effort whenever possible
      » Think: When choice between elevator and stairs, what do you take?

An application

• Applying Adherence Engineering: Central Line Associated Bloodstream Infections (CLABSI)
An application

– CLABSI facts
  • In US approx. 250,000 patients develop CLABSI annually
  • Excessive length of stay (LOS) = 7 days
  • 4-20% mortality rate
  • Costs: $35,000 - $56,000
  • 1/3rd of all preventable death in HC

– Solution: Checklists
  • Pronovost, et al., 2006; Gawande, 2009

An application

– Problems with checklists
  • Require multi-tasking or additional staff to supervise
  • Increase in overall cognitive task load
  • Lead to checklist fatigue
  • Facilitate expectation driven perception
  • Domain of application: Engineered vs. natural systems
An application

• Central line maintenance (CLM)
  – A “brittle” procedure
    • Timing of CLM
      – Based on need
      – Identification of last CLM; often missing date on dressing
    • Complexity of CLM
      – Maintenance more than 25 steps
      – If provider error rate is p(error)=.01
        » 25 step task p(successful execution) = 0.77
  • Performance
    – Novice nurse performance increases likelihood of CLABSI three-fold
    – CLABSI risk increases five-fold with inappropriate central line care

An application

• Equipment
  – Current equipment does not support clinicians; nurses spend approx. 5% of their work time searching for equipment
  – Opportunity to redesigning the task / equipment applying Adherence Engineering
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

An application

• Building an alternative: Applying AE

<table>
<thead>
<tr>
<th>Principle</th>
<th>Goal</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adherence</td>
<td>Make use intuitive</td>
<td>Tabs to open kit, visibility of flags of pockets</td>
</tr>
<tr>
<td>Task-intercept</td>
<td>Provide structure and overview of task</td>
<td>Sequential order of packets, where red is pour,</td>
</tr>
<tr>
<td>Nudging</td>
<td>Support adherence by suggesting desirable</td>
<td>Proving hand gel in packets, providing pain to</td>
</tr>
<tr>
<td>Smart defaults</td>
<td>Help select desirable actions/</td>
<td>Selection of materials that if used follow best</td>
</tr>
<tr>
<td></td>
<td>materials to perform activity</td>
<td>practices (should be purchased in sets)</td>
</tr>
<tr>
<td>Feedback</td>
<td>Allow easy resumption and assessment of current</td>
<td>Packets are empty after completion of step,</td>
</tr>
<tr>
<td></td>
<td>performance</td>
<td>resumption</td>
</tr>
<tr>
<td>Minimizing cognitive</td>
<td>Support the execution of a task by</td>
<td>Checking of record activities, site, and labels,</td>
</tr>
<tr>
<td>effort</td>
<td>reducing the required cognitive resources</td>
<td>structured sequence, reduction in planning needs</td>
</tr>
<tr>
<td>Minimizing physical</td>
<td>Make adherence convenient</td>
<td>Reduction of walking requirements (e.g., hand gel)</td>
</tr>
<tr>
<td>effort</td>
<td></td>
<td>dispenser, supplies room to pick up-saving time,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>no repeated need to get forgotten materials</td>
</tr>
</tbody>
</table>

– Goal: Making adherence effortless

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
An application

- **Method**
  - Observational method (time-motion paradigm)
    - Data collection on tablet PC in ICUs
    - Trained observers (2 ICU nurses)
      - 2 weeks of training
      - Inter-rater reliability >95%
    - 16 month (5 month pre-intervention; 11 month post-intervention) data collection
  - Participants
    - 95 nurses (85 female)
    - Mean experience = 6.7 years
    - All participant nurses received training on kit use
  - Patients
    - n = 151
    - Total of 218 CLM procedures

<table>
<thead>
<tr>
<th></th>
<th>Line Days</th>
<th>CLABSI</th>
<th>CLABSI RATE/1000 line days</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Intervention</strong></td>
<td>7253</td>
<td>16</td>
<td><strong>2.21</strong> (95% CI: 1.26-3.58)</td>
</tr>
<tr>
<td><strong>Post-Intervention</strong></td>
<td>4570</td>
<td>0</td>
<td><strong>0.0</strong> (95% CI: 0-0.81)</td>
</tr>
</tbody>
</table>

Incidence Rate Ratio = 0 (95% CI: 0-0.41); *P<.001*
An application

• Results
  – Aseptic technique
  • Adherence to best practice
    – Hand sanitization and maintaining aseptic conditions

<table>
<thead>
<tr>
<th></th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>Composite score</td>
<td>128</td>
<td>2.8</td>
</tr>
</tbody>
</table>

(Composite score max=8)

An application

Adherence to best practices

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Pre (n=128)</th>
<th>Post (n=90)</th>
<th>Odds Ratio (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHG Scrub</td>
<td>102 (81.6%)</td>
<td>80 (96.4%)</td>
<td><strong>6.01</strong> (1.74-20.7)</td>
<td>0.005</td>
</tr>
<tr>
<td>Anti-Microbial bandage</td>
<td>114 (97.4%)</td>
<td>79 (93.3%)</td>
<td>0.069 (0.14-3.52)</td>
<td>0.66</td>
</tr>
<tr>
<td>Hand sanitization</td>
<td>68 (58.6%)</td>
<td>79 (89.8%)</td>
<td><strong>6.2</strong> (2.83-13.55)</td>
<td>0.000</td>
</tr>
<tr>
<td>Disinfect catheter hub</td>
<td>30 (28.0%)</td>
<td>63 (76.8%)</td>
<td><strong>8.51</strong> (4.38-16.53)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

An application

Item omissions (%)

<table>
<thead>
<tr>
<th>Item</th>
<th>omissions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>YES</td>
<td></td>
</tr>
</tbody>
</table>

An application

Violations

<table>
<thead>
<tr>
<th>Violations</th>
<th>Median number of violations</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-intervention</td>
<td></td>
</tr>
<tr>
<td>post-intervention</td>
<td></td>
</tr>
</tbody>
</table>

P<0.01
50% reduction in violations

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
An application

- Changes in kit design based on user feedback

Smaller form factor

Non-Sterile

Sterile Portion

An application

- Cost effectiveness of CLM kit
  - Constructed Markov model to compare cost effectiveness of kit compared to standard care (individual collection of items)
  - Assumptions
    - CLABSI cost $45,685
    - Excess LOS
      » 6.9 ICU days
      » 3.5 general ward days

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

An application

— Model input data
  • Cost of CLM kit $29.45
  • Cost of separate components $21.82
  • CLABSI rate during observation 0, i.e., 100% reduction
  • Sensitivity analyses
    — Additional analysis with rate reduction ranging from 100% to 1%

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline CLABSI rate</td>
<td>3.1 (1.6, 5.1)</td>
</tr>
<tr>
<td>Reduction in CLABSI rate with CLM kit</td>
<td>100% (0%, 100%)</td>
</tr>
<tr>
<td>Baseline mortality</td>
<td>15.5% (8.0%, 19.0%)</td>
</tr>
<tr>
<td>Mortality rate: ICU</td>
<td>2.0% (0.2%, 5.5%)</td>
</tr>
<tr>
<td>Mortality rate: ICU for CLABSI patients</td>
<td>2.27 (1.15, 4.96)</td>
</tr>
<tr>
<td>Extra days in ICU</td>
<td>6.9 (3.5, 9.6)</td>
</tr>
<tr>
<td>Extra days on hospital ward</td>
<td>3.5 (3.0, 5.0)</td>
</tr>
<tr>
<td>Mean number of central line days per patient</td>
<td>7.14 (2.0, 13.3)</td>
</tr>
<tr>
<td>Utility</td>
<td>0.66 (0.5, 0.8)</td>
</tr>
<tr>
<td>Cost CLABSI</td>
<td>$66,405 (31,372, 86,201)</td>
</tr>
<tr>
<td>Vascularitis</td>
<td>$154 (145, 165)</td>
</tr>
<tr>
<td>Cost per day (wound)</td>
<td>$3,822 (3,577, 4,068)</td>
</tr>
<tr>
<td>Cost per day (ICU)</td>
<td>$6,288 (5,000, 7,272)</td>
</tr>
<tr>
<td>Kit</td>
<td>$29.45 (25, 35)</td>
</tr>
<tr>
<td>Kit components separately</td>
<td>$21.82 (15, 25)</td>
</tr>
</tbody>
</table>

An application

— Results
  • 100% reduction of CLABSI rate
    — Kit approach saves $860 / per patient
  • 50% reduction of CLABSI rate
    — Kit approach saves $400 / per patient
  • Sensitivity analysis
    — Kit saves money even with a CLABSI risk rate reduction of 2%

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
An application

• Discussion
  – Elimination of CLABSI beyond study interval for 18 month
  – Kit was adopted in hospital and is currently in use
  – Clear improvement in adherence to best practices, but still space for improvement
  – Fewer item omissions

An application

• Discussion
  – Overall a significant cost reduction associated with the use of a CLM kit
    • A dominant strategy to improve care and reduce cost per patient
  – Support for Adherence Engineering framework in the context of infection prevention
An application

• Discussion
  – Intervention in conjunction with other approaches
    • Organizational level feedback (providing unit-based performance data)
    • Organizational redesign (weekly, scheduled central line maintenance)
  – Application in other domains (aviation), especially maintenance tasks

Contact

http://www.adherenceengineering.org
Frank.Drews@psych.utah.edu

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

October 13  UPDATE ON STRATEGIES FOR CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE
Prof. John Boyce, J.M. Boyce Consulting
Sponsored by Sealed Air Diversey Care (www.sealedair.com)

October 19  (South Pacific Teleclass) TECHNOLOGY FOR MONITORING HAND HYGIENE IN THE 21ST CENTURY – WHY ARE WE USING IT?
Prof. Mary-Louise McLaws, University of New South Wales, Australia

October 20  (FREE Teleclass) THE HISTORY OF CBIC AND WHY CERTIFICATION IS STILL IMPORTANT TODAY
Certification Board of Infection Control

October 27  ANTIMICROBIAL ENVIRONMENTAL SURFACES IN HEALTHCARE SETTINGS – CAN THEY REALLY BE BENEFICIAL?

www.webbertraining.com/schedulept.php

TELECLASS EDUCATION
2001–2016
15 YEARS

THANKS FOR YOUR SUPPORT

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com
Adherence Engineering to Reduce Central Line Associated Bloodstream Infections
Prof. Frank Drews, University of Utah
A Webber Training Teleclass

Thanks to Teleclass Education

**PATRON SPONSORS**

- [Sealed Air](www.sealedair.com)
- [VIROX](www.virox.com)
- [World Health Organization](www.who.int/gpsc/en)

Hosted by Dr. Hugo Sax, University Hospital of Zurich
www.webbertraining.com