Socio-technical Systems Safety in Health Care:
We need a new lens and practice paradigm!

Yvonne Toft, CQUUniversity, Australia
1st Career – Student nurse to RN
2nd Career – The world is my oyster!
3rd Career – Industrial Nurse
-> Rehabilitation Unit Manager
-> Remote Area Nurse (Mining)
4th Career – Safety Adviser -> Accident Investigator -> Analysis of equipment design
Hierarchy of Control

Apply the highest level of control commensurate with the risk level—lower value controls may be used in the interim until long-term controls are implemented.

**ELIMINATION**

**SUBSTITUTION**

**ENGINEERING**

**ADMINISTRATIVE**

**BEHAVIOR**

**PPE**

Increasing effectiveness and sustainability

Increasing participation and supervision needed
5th Career - Academic

Realisation that not everybody ‘gets’ it!!!
No longer working in Health Care but rather, a pilot of complex socio-technical systems design ...
1. In 2000-01, 8% ($4.0 billion) of total allocated health expenditure was spent on persons who experienced injuries – 6.5% ($3.2 billion) related to non-work related injuries (in the home, recreation etc).

2. The annual cost of accidents on Australian roads totals $17 billion dollars a year representing 2.3% of GDP!

3. In 2005-06, the cost of work-related injuries and illness was estimated as $57.5 billion dollars or 5.9% of GDP.

4. The 2004-05 NHS indicated that:
   – 18% of the population (3.6 million persons) had sustained a recent injury (in the previous four weeks).
   – Of all employed persons aged 15 years and over, 7% had received an injury while working for income in the four weeks prior to interview.

TOTAL ANNUAL COST OF ACCIDENTAL TRAUMA AND DISEASE
CIRCA: $77.7 BILLION OR circa 7.8% of GDP

There is a significant cost to our Health Care system when our workers are exposed to injury and disease!

Citation: Connelly L. & Supanagan R. (2006), The economic costs of road traffic crashes: Australia, states and territories, Accident Analysis & Prevention, Vol 38, Issue 6, November 2001, PP1087-1093, Elsevier
Runciman and Moller (2001) estimated that iatrogenic injury in Australia results in **direct medical costs of over $2 billion per year** and that the total lifetime cost of such preventable injury may be twice that amount. They also note that there is a heavy toll in human costs on both those who are harmed and those who care for them. Furthermore, medical misadventure consumes over half the amount spent on compensation and insurance by State Treasury Departments.
### Table 10: Data on adverse events in health care from several countries

<table>
<thead>
<tr>
<th>Study</th>
<th>Study focus (date of admissions)</th>
<th>Number of hospital admissions</th>
<th>Number of adverse events</th>
<th>Adverse event rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States (Harvard Medical Practice Study)</td>
<td>Acute care hospitals (1984)</td>
<td>30 195</td>
<td>1 133</td>
</tr>
<tr>
<td>2</td>
<td>United States (Utah–Colorado study)</td>
<td>Acute care hospitals (1992)</td>
<td>14 565</td>
<td>475</td>
</tr>
<tr>
<td>3</td>
<td>United States (Utah–Colorado study)(^a)</td>
<td>Acute care hospitals (1992)</td>
<td>14 565</td>
<td>787</td>
</tr>
<tr>
<td>4</td>
<td>Australia (Quality in Australian Health Care Study)</td>
<td>Acute care hospitals (1992)</td>
<td>14 179</td>
<td>2 353</td>
</tr>
<tr>
<td>5</td>
<td>Australia (Quality in Australian Health Care Study)(^b)</td>
<td>Acute care hospitals (1992)</td>
<td>14 179</td>
<td>1 499</td>
</tr>
<tr>
<td>6</td>
<td>United Kingdom</td>
<td>Acute care hospitals (1999–2000)</td>
<td>1 014</td>
<td>119</td>
</tr>
<tr>
<td>7</td>
<td>Denmark</td>
<td>Acute care hospitals (1998)</td>
<td>1 097</td>
<td>176</td>
</tr>
</tbody>
</table>

Source: World Health Organization, Executive Board 100th session, provisional agenda item 3.4, 5 December 2001, EB 100/9.

\(^a\) Revised using the same methodology as the Quality in Australian Health Care Study (harmonising the four methodological discrepancies between the two studies).

\(^b\) Revised using the same methodology as Utah–Colorado Study (harmonising the four methodological discrepancies between the two studies). Studies 3 and 5 present the most directly comparable data for the Utah–Colorado and Quality in Australian Health Care studies.
A major cause we are told: Human error!

I propose that

- If we want to prevent human error we need to take a systems safety approach
- human factors is a design science and is transdisciplinary
- we will have many more opportunities to address human error across our system by tweaking the design of equipment and systems rather than by tweaking the design of people and their behaviour!
- human factors in health care is REALLY about the design of complex socio-technical systems of which humans are an integral part!
What is Human Factors?

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.

http://www.iea.cc/whats/index.html
Design cues influence people performance …
Human Factors applies to design across the system lifecycle ...
Maintenance:
Scheduled maintenance specified by manufacturer
Manufacturer vs BME (Biomedical Engineering) personnel
Software upgrades
Highly skilled BME personnel required (electronics/mechanics) required

Operation:
Testing by local biomedical engineers
Operator training/familiarisation
Ergonomics: manoeuvrability, location/design of controls

Operation failure:
Incorrect software installation, incorrect procedure followed.
Insufficient training for all clinical situations/locations encountered (e.g., non-MRI compatible machine in MRI)
Confusion between different machine operation (different manufacturers or models).
Tipping hazards: machine CoG high, multiple cords/pipelines on floor to hinder castors (heavy machine).
Physical injury – heavy machine, poorly placed grab handles

Traditionally mechanical knobs (anticlockwise) vs electronic (clockwise)
Design brief:
Affordable level crossings i.e. redesign passive level crossings to reduce train-vehicle collisions ...
When questioned about his design assumptions...

“my first assumption had to be that people would use the crossing properly otherwise how would I be able to assign a risk score ... “

Now..... Human Factors Engineer at European Space Agency!
Investigation of human error is only as useful as the lens we wear while investigating ...

Even unsophisticated HOLISTIC models can begin to illustrate the complexity that underpins human error across the system lifecycle and helps us identify the genesis of the errors in our systems.
However, if we complete investigations with a linear lens …

1950 – Bird & Germain – Loss Causation Model

1990 – Reason – Model of Organisational Accidents
... and rely on error classifications ...

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Permanent disability</th>
<th>High preventability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complication of, or failure in, the technical performance of an indicated procedure/operation</td>
<td>1017 (34.6%)</td>
<td>144 (14.2%)</td>
<td>504 (49.6%)</td>
</tr>
<tr>
<td>Failure to synthesise, decide and/or act on available information*</td>
<td>465 (15.8%)</td>
<td>114 (24.5%)</td>
<td>355 (76.3%)</td>
</tr>
<tr>
<td>Failure to request or arrange investigation, procedure or consultation*</td>
<td>346 (11.8%)</td>
<td>111 (32.1%)</td>
<td>293 (84.7%)</td>
</tr>
<tr>
<td>Lack of care or attention, failure to attend*</td>
<td>320 (10.9%)</td>
<td>83 (25.9%)</td>
<td>250 (78.1%)</td>
</tr>
<tr>
<td>Misapplication of, or failure to apply a rule; or use of a bad or inadequate rule*</td>
<td>258 (8.8%)</td>
<td>66 (25.6%)</td>
<td>233 (90.3%)</td>
</tr>
<tr>
<td>Violation of a protocol or rule*</td>
<td>140 (4.8%)</td>
<td>39 (27.9%)</td>
<td>111 (79.3%)</td>
</tr>
<tr>
<td>Unable to code</td>
<td>92 (3.1%)</td>
<td>16 (17.4%)</td>
<td>49 (53.3%)</td>
</tr>
<tr>
<td>Other</td>
<td>83 (2.8%)</td>
<td>24 (28.9%)</td>
<td>64 (77.1%)</td>
</tr>
<tr>
<td>Acting on insufficient information*</td>
<td>53 (1.8%)</td>
<td>14 (25.4%)</td>
<td>43 (81.1%)</td>
</tr>
<tr>
<td>Slips and lapses; errors due to &quot;absentmindedness&quot; in activities in which the operator is skilled*</td>
<td>46 (1.6%)</td>
<td>8 (17.4%)</td>
<td>42 (91.3%)</td>
</tr>
<tr>
<td>Failure to continue established management*</td>
<td>43 (1.5%)</td>
<td>7 (16.3%)</td>
<td>37 (86.0%)</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>33 (1.1%)</td>
<td>10 (30.3%)</td>
<td>33 (100.0%)</td>
</tr>
<tr>
<td>Electively practising outside area of expertise</td>
<td>30 (1.0%)</td>
<td>13 (43.3%)</td>
<td>24 (80.0%)</td>
</tr>
<tr>
<td>Questionable practice ethics</td>
<td>14 (0.5%)</td>
<td>8 (57.1%)</td>
<td>13 (92.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>2940 (100%)</td>
<td>657 (22.3%)</td>
<td>2051 (69.8%)</td>
</tr>
</tbody>
</table>

* Failure of cognitive function.

† Total is greater than number of AEs (2351) as the categories were not mutually exclusive.
We fail to really learn about the true complexity ...
Some theorists have tried to capture the nature of complex socio-technical systems ....

2004 – Hollnagel – Functional Resonance Accident Model - FRAM
... and complex accident modelling, but when it comes to using these, they either get lost in translation or end up like this ....

Hollnagel: Functional Resonance Accident Method
However, even our most enlightened safety minds fall into our design induced traps …

(we tried to knock Erik Hollnagel off his feet with this design!!!!!)
There are so many questions still to ask!

... sometimes the most obvious questions are the best place to start, yet still they remain unanswered with any evidence base...
Why do functionally and technically robust designs fail?

We can’t always influence design but our investigations MUST create the evidence base for issues at the interface!
Emergency Call bells (push button) located in all theatres, each bedspace in recovery, preadmission and in toilets. All bells linked to central unit, which alerts staff via audible alarm, and LED display units, located in each theatre and in several other locations throughout the theatre suite, which give the location of the alarm.

Call button obscured by other equipment in theatre.
Inadvertent activation by equipment pushed against call button
Button located next to light switch in bathrooms – poor location choice

Installation Company

3rd party installs buttons, wiring and LED panels.
Software to align activated button with location on LED panel. Some locations given abbreviation.

Dissimilar mental model between installer and purchaser.
Incorrect wiring
Software programming mistakes
Unclear/ambiguous location abbreviations chosen

Maintenance Dept.

System function checked weekly.
Problems rectified by electrician

Forget to check system
Delays in fixing problems due to workload.
Equipment to fix system presents hazard to normal ward traffic (e.g. ladders in corridor to fix ceiling mounted LED panel)
Inadvertent failure from maintenance on separate co-located equipment (e.g. wiring loom-wrong wire cut).
What drivers influence design outcomes?

<table>
<thead>
<tr>
<th>Matter of interest</th>
<th>Factor 1 Pragmatist</th>
<th>Factor 2 Democrat</th>
<th>Factor 3 Traditionalist</th>
<th>Factor 4 Strategist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>Safety</td>
<td>User acceptance</td>
<td>Safety</td>
<td>Cost-benefit</td>
</tr>
<tr>
<td>Approach</td>
<td>Practical &amp; socio-technically realistic</td>
<td>Democratic &amp; socially responsible</td>
<td>Functionalist &amp; technically rational</td>
<td>Calculated &amp; socio-technically astute</td>
</tr>
<tr>
<td>Priority</td>
<td>System wellbeing</td>
<td>Human system</td>
<td>Sound engineering</td>
<td>Business</td>
</tr>
<tr>
<td>End-user role</td>
<td>Valued subject matter expert</td>
<td>Gatekeeper to project success</td>
<td>Recipient of support</td>
<td>Necessary inconvenience</td>
</tr>
<tr>
<td>Human Factors professionals</td>
<td>Design partner</td>
<td>Ensure human factors are addressed</td>
<td>Not mentioned</td>
<td>Value is experience dependent</td>
</tr>
<tr>
<td>System focus</td>
<td>Overall system – Systems have humans</td>
<td>Usable system – user solution not an engineer’s</td>
<td>Cutting edge – humans use systems</td>
<td>Anticipates future trends – has main user needs</td>
</tr>
<tr>
<td>Productivity</td>
<td>Increases when safety is assured</td>
<td>Increases when technology incorporates end-user preferences</td>
<td>Increases through a competitive advantage</td>
<td>Increases by strategic and astute action</td>
</tr>
<tr>
<td>Safety</td>
<td>Paramount for business success</td>
<td>No risk, no gain</td>
<td>Paramount – No go if it is unsafe</td>
<td>A concern, but not the primary focus</td>
</tr>
<tr>
<td>Learning support</td>
<td>Reduced when design matches end-user needs</td>
<td>Hands-on essential. Online training offers no real benefit</td>
<td>Full end-user training required</td>
<td>Inadequately trained user will delay project implementation</td>
</tr>
<tr>
<td>Technical support</td>
<td>Reduced when design matches end-user needs</td>
<td>Not a primary focus</td>
<td>Necessary to support end-user</td>
<td>Essential during implementation</td>
</tr>
<tr>
<td>Key to success</td>
<td>Involve end users</td>
<td>Satisfy end users</td>
<td>Sound engineering</td>
<td>Involve end users astutely</td>
</tr>
</tbody>
</table>
We need high fidelity investigations!!

Rubbish in = Rubbish out!
... shallow investigations in relationship to human error / system and equipment interface issues become even less useful when we try to base our learning on data like this ....
Is this ‘really’ reflective of what is happening in modern day complex socio-technical system?
If we want to learn about the genesis of human error …

We need to find ways to visualise the complex reality of our environment in a way that enables us to start to see relationship between people and other elements of the system … NOT shadow box with data!!!
SAFE-Net Method - STEPS

1. Collect the data – Contributing Factors

2. Convert the data to relationships

   **Rationale Used**
   
   Accident = party
   
   Factor = person

3. Use SNA program/s

4. Examine and explore resulting model
Centrality Measures using Social Network Analysis

- **Betweenness Centrality**

- A measure of how much removing a factor would disrupt the connections between one factor and another factor
Yard Derailments – Only Top 9 Factors Shown
Yard Derailments – Risk/Change Management Factor Removed
Communication Error Factor Removed
Wear Maintenance Factor Removed – Network Broken
SAFE-Net Method - Results

- Accident Model representing the relationship between the contributing factors – the network
- Better representation of the connectiveness of the parts in the socio-technical system under investigation
- Easy understood via visual representations
- Evidence based data (Centrality Measures) to identify where to put safety efforts
- Supports understanding the genesis of human error related design issues!
We need ‘just’ & ‘independent’ investigations and analysis centred on learning!
Basic risk management maturity chart

No Care Culture | Blame Culture | Compliance Culture | Ownership Culture | Way of Life

Basic → Reactive → Compliant → Proactive → Resilient

Accept that incidents happen → Prevent a similar incident → Prevent incidents before they occur → Tune the systems through ownership → Way we do business

No Risk Assessment | Reactive Risk Assessment | Regular Risk Assessment | Proactive Risk Assessment | Integrated Risk Assessment
Poor Investigation | Limited Investigation | Causal Investigation | Open Causal Investigation | Proactive Investigation
No Auditing | Ad hoc Auditing | Regular Auditing | Targeted Auditing | External Auditing

© Erik Hollnagel, 2014
Complex socio-technical systems investigation and problem solving requires a transdisciplinary approach …
We need transdisciplinary solutions to complex problems …
We need to act now!
Our current Emergency & Safety Sciences offerings … how can we use education & training to make a difference???

VET & BACHELOR DEGREES
- Cert IV in Work Health & Safety
- Cert IV in Paramedical Science
- Cert IV in Rail Safety Investigation
- Diploma of Work Health & Safety
- Diploma of Paramedical Science
- Associate Degree in OHS
- Bachelor of Accident Forensics
- Bachelor of Emergency Service
- Bachelor of Occupational Health & Safety
- Bachelor of Paramedic Science

MASTER & DOCTORAL DEGREES
- Master of Safety Science (Air Safety Investigation)
- Master of Safety Science (Rail Safety Investigation)
- Master of Safety Science (Road Safety Investigation)
- Master of Safety Science (Industrial Accident Investigation)
- Master of Safety Science (Human Factors Engineering)
- Master of Safety Science (Risk Engineering)
- Master of Safety Science (Accident Forensics)
- Master of Safety Science (Emergency Services Safety)
- Master of Advanced Safety Science Practice
- Master of Paramedic Science (Paramedic Practitioner)
- Masters by Research
- PhD & Professional Doctorate
- Master of Advanced Safety Science Practice

GRADUATE CERTIFICATES & DIPLOMAS
- Graduate Certificate in Emergency & Disaster Management
- Graduate Certificate in Fatigue Risk Management
- Graduate Certificate in Accident Phenomenology
- Graduate Certificate in Advanced Accident Investigation Practice
- Graduate Certificate in Advanced Safety Science Practice
- Graduate Diploma of Accident Investigation
- Graduate Diploma of Occupational Health & Safety
- Graduate Diploma of Paramedic Science (Critical Care)
- Master of Safety Science (??????)
We want to change the world - do you??????

The future??????

CQU FORENSIC INVESTIGATION TEACHING LABORATORY, BUNDABERG, 2016