Medical Error: Knowing (and herding) the Elephants

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The Evolution of Bovine Practice
...the first national convention devoted entirely to the bovine

Medical Error: An act of omission or commission in planning or execution that contributes or could contribute to an unintended result (Grober and Bohen, 2005)

Two physicians planted my ‘Mind Bugs’ on medical error

Evidence of problems with common practices
Tonsillectomy Study (Pseudodoxia Pediatrics NEJM 232:691)

On Being Wrong – Kathryn Schulz
Doctors Make Mistakes: Can we talk about that? - Brian Goldman

Ronald J Prineas, MD PhD
Cardiovascular Epidemiologist
University of Sydney
University of London
London School of Hygiene and Tropical Medicine

David M Eddy, MD PhD
Medical Decision Making, Medical Error and Medical Outcomes & Quality Control
University of Virginia MD, 1968
Stanford Engineering-Economic Systems PhD, 1978

Evidence of problems with common practices
Tonsillectomy Study (Pseudodoxia Pediatrics NEJM 232:691)

Doing it over again

Evidence of problems with common practices
Tonsillectomy Study (Pseudodoxia Pediatrics NEJM 232:691)

Evidence of problems with common practices
Tonsillectomy Study (Pseudodoxia Pediatrics NEJM 232:691)
If they're having those problems in that environment . . .

... what was I having in mine?

- Square feet of spotless stainless steel
- Uniformly bright lighting
- Soothing classical music piped in
- 24/7 staffed stat labs

- Acres of egesta and rusty pipe
- Barnyard mercury vapor light
- Vacuum pump in midst of wash cycle
- 2 day UPS lab with 2 PM cutoff

Admittedly, these are likely tough ones, not "slam dunks"

Tonsil removal was a Coin Flip!

115 (54%) Tonsillectomy Not Recommended
64 (56%) Tonsillectomy Recommend
51 (44%) Tonsillectomy Recommended

What like this is happening in animal health?

Absence of evidence is not evidence of absence. If we haven’t looked, we don’t know!

And again

Dr. Eddy’s JAMA essay on medical decision problems

Eddy DM. The Challenge. JAMA 263:287-290

Summarized findings similar to the earlier Tonsillectomy study:
- Chance of tonsil removal was 8% in one community, 70% in a neighboring community
- Given written descriptions of surgical problems, 50% of surgeons recommended surgery, 50% not
- When surveyed two years later, 40% changed their recommendations

"Physicians are in the impossible position of facing uncertain outcomes from different actions, but having to act anyway"
"Variability occurs because physicians must make decisions about problems in complex systems under difficult circumstances with little support"

How well are veterinarians dealing with systems having another level of complexity (farms) and even less support doing?

If they're having those problems in that environment . . .

... what was I having in mine?

Autopsy evidence of physician diagnostic error rates

Changes in rates of autopsy-detected diagnostic errors over time: A systematic review
JAMA 289(21):2849-2856

Analyzed 53 autopsy series published 1966 – 2002:
- 24% major error rate (4% - 50%)
  - Involved 1st cause of death but did not affect outcome
- 9% class I error rate (0% - 21%)
  - Likely resulted in death!
- Authors’ conclusions:
  - Of 850,000 dying in hospitals per year, 35,000 are due to diagnostic error
  - Advancing technology alone is not the answer!

What is the diagnostic error rate in veterinary medicine?

Diagnostic error rate evidence from bovine medicine

The post-mortem examination in ruminants and its possible benefit to ruminant clinical medicine / Comp Path 15(2-3):202-216

6 year retrospective study of 1,370 bovine cases with both a pre-mortem clinical diagnosis and a post-mortem necropsy diagnosis:
- 21% complete agreement (286)
- 35% minor finding missed (482)
- 36% major finding missed (889) (24% Human)
- Had bearing on death
- 8% complete discrepancy (113) (9% Human)

My 'statistical' conclusion: The rates look surprisingly similar! An optimist might conclude that by comparison vets are doing fine
Medical error approach is modeled after aviation safety work, which was initiated by the high fatality rate of air mail pilots

USPS Transcontinental Airway System – 1920’s to 40’s

70’ yellow arrows, 53’ electric light towers every 10 of the 2,600 miles from New York City to San Francisco

Seminal paper: Human error: Models and management

Two aspects of human fallibility:
- Historical focus on the Individual(s):
  - Premise – error arises from aberrant mental processes, e.g. forgetfulness, inattention, poor motivation, carelessness, negligence, recklessness
  - Just World Hypothesis – bad things happen to bad people
  - Typical Solution – protocols, disciplinary measures, naming, blaming, shaming
  - Consequence – errors are hidden, procedures aren’t improved
- Current focus on the System:
  - Premise – humans are fallible, errors are expected consequences, not causes
  - Systemic factors - recurrent error traps occur in organizational processes
  - Solution - can’t change human so change the conditions under which human works
  - Consequence – continual procedural improvement and error reduction

Reason’s ‘Swiss Cheese’ accident causal chain

Organizational Leadership

Culture & Mission

Training & Supervision

Equipment & Maintenance

Sharp End

Active Factors

Latent (Hidden) Factors, System Preconditions

Blunt End

Example: Dana Air Flight 0992 accident report

Individual Unsafe Act

Bovine veterinary medical error and human medical error occur in completely different system structures

Physicians are embedded in a care system in which the patients are individuals who come into the system

Most bovine veterinarians are individuals delivering care where the patients are embedded in different systems (farms)

Example - Medication errors
- Physicians:
  - Committed by a person within the physician’s span of control, directly or indirectly
  - The person making the error is often a trained professional within the same system
- Veterinarians:
  - Committed by individuals in a system but outside of the veterinarian’s control
  - The person making the error is usually not a trained professional

How can one gain an understanding of the cognitive aspects of the ‘sharp end’ of medical error? Popular press books

JP: Researchers author popular books to press their argument with their peers

Problem: ~50% of popular psychology info is bogus

To avoid the bogus, check:
- PubMed to see if the author has a research publication record
- If the book has extensive notes and scientific literature references

So what is the fundamental reason why we humans make the errors we do?

I may well be sawing the limb off but:

For better or for worse, it’s because that is the way we’re wired!

Jaak Panksepp, PhD

Affective Neuroscientist, ‘rat tickler’

University of Pittsburgh

University of Massachusetts

University of Sussex
Well designed accident prevention processes compensate for our psychological limitations

- Careful (2017) is authored by a research psychologist working in NASA's Human Systems Integration Division
- He is an Airline Transport Rated pilot with Boeing 737 and Airbus 320 type ratings among others
- Addressing the psychology of safety across our lives, the first part addresses cognitive processes relevant to medical error
  - Paying attention
  - Making errors
  - Thinking ahead
- Well written and extensively referenced, the book is an enjoyable read

Our working memory capacity is a major cognitive bottleneck

- Working memory holds task-relevant information for the task we are focused on
- New items not processed into long term memory vanish without a trace
- Capacity is only 4 to 7 items, 1 if complex and unfamiliar
- We naturally 'chunk' items to improve fit
  - Phone numbers and social security numbers into 3 blocks
- Familiarity increases 'chunk' size compared to unfamiliarity
  - nur, phd, bvd, fbi, fbi, cbs, sos, sir, usa, att
- Concept labels (memes) – diseases, procedures, ...
- Switching tasks requires resetting working memory, which requires much subconscious (behind the curtain between acts) processing
  - Text messaging at a stop light reduces attention for up to 20 sec after light changes
- To demonstrate to yourself – First watch a TV show episode while working on a task on your laptop and then watch the rerun while not; you’ll see two different shows

Checklists reduce error by reducing the effect of distractions on completing the sequential steps of routine tasks

- Routine task steps are performed with automaticity, not registering in memory
- Task attention is broken by internal or external interference
- Attention strength declines with increasing automaticity, stress, sleep deprivation and age (senior moments)
- To establish & maintain use, routine task checklists must be carefully designed
  - Pain of use < Risk from nonuse
  - Opportunity for electronic IA (Siri)?

Errors are usually caused by chain of events, rarely a solitary single event

Our reasoning functions as two systems, conscious and subconscious

- System I: Conscious Rider
- System II: Subconscious Choice!
- All sensory input

Because all sensory input goes to the subconscious first, relative size approximates cognitive processing balance

The two processes differ in speed, function, and learning

<table>
<thead>
<tr>
<th>System I: Thinking fast</th>
<th>System II: Thinking slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>The massive Elephant</td>
<td>The small Rider</td>
</tr>
<tr>
<td>Adaptive unconscious</td>
<td>Conscious self</td>
</tr>
<tr>
<td>Automatic, effortless, no sense of thought control</td>
<td>Deliberate, effortful, requires concentration and energy expenditure</td>
</tr>
<tr>
<td>Dominates under stress, alarm or anger</td>
<td>Capacity exhausted under stress</td>
</tr>
<tr>
<td>Habitual, trained by repetition</td>
<td>Abstract</td>
</tr>
<tr>
<td>Emotional, intuition, &quot;gut feeling&quot;</td>
<td>Rational, reasoning, logical</td>
</tr>
<tr>
<td>Implicit learning, trained by System I</td>
<td>Explicit learning</td>
</tr>
<tr>
<td>Impulsive, instinctual behavior</td>
<td>Controller, often quenching impulses</td>
</tr>
<tr>
<td>Danger of Complacency</td>
<td>Danger of Inattention, Distraction</td>
</tr>
<tr>
<td>The 'pattern-matching' expert or teacher</td>
<td>The novice employee or student</td>
</tr>
</tbody>
</table>

Shane Fredrick's cognitive reflection tests illustrate the differences between intuition (System I) and conscious reason (System II)

A ball and bat cost $1.10. The bat costs one dollar more than the ball
How much does the ball cost?
  a) $0.05
  b) $0.10

In a lake, there is a patch of lily pads. Every day, the patch doubles in size
If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?
  a) 24 days
  b) 47 days

Two ‘take homes’:
1. Alerted, System II educates System I, correcting System I error
2. We don't process exponential functions well intuitively (retirement investment)
The power of System 1 (fast thinking) is amazing

Most understand this quickly:

Aoccdng to a rscheearch at Cmbridge Universtis, it doesn't mttaer in wahn cedit the ltters in a wrod are, the olny ipmootnt tihng is talt the frist and lats Ittee be at the rght pclae. Ths can be a toasl mses and you can stll rd it wouthit porbelm. Ths is bcusea the huamn mdn does not rd evry lttier by stllef, but the wrod as a whole.

Given above and SpellCheck, one might wonder why we invest so much time in learning to spell

But this also gives clues to why it is easy to misread things such as labels

By the way, there is more to this meme than is represented above -

Google 'Davie Cambrige jumbled letters'

Dual-process reasoning is being incorporated into clinical teaching in hopes of reducing cognitive bias

The only strategy shown to reduce diagnostic error committed by experts

After expert makes diagnosis, they review every fact in the case to make sure that it is accounted for by the diagnosis

Dual-process is also impacts communication effectiveness

A lecture is the process whereby the notes of the teacher become the notes of the student without passing through the mind of either

The Environment Recipient's notes - the process what order the first and you

Aoccdng to modern we understand this is read ervey lttier by the student without passing through the mind of either

Human reasoning like playing pool on a table with a warped (biased) slate

Takeoff on Steven Pinker's The Blank Slate: The modern denial of human nature (2002)

• Nature wired biases into our brains
• Evidence shows that knowledge of these biases does not significantly reduce their effect
• Processes must be designed to minimize the opportunity for each
• Example: collective application of the scientific method and process: Published RBCT's

Multiple cognitive biases may be involved in a medical error

Cognitive biases associated with medical decisions: a systematic review

BMC Medical Informatics and Decision Making (2016) 16:138

The big ones affecting veterinary decision-making likely include:

• Anchoring effect
• Availability bias
• Confirmation bias
• Framing effect
• Hindsight bias
• Lead-time bias
• Overconfidence bias
• Recency effect
• Search satisfying bias
• Survivorship bias

The Big Question: Why do we have these biases?
**Error Mgmt Theory: Nature biased us toward the least costly reasoning error**

<table>
<thead>
<tr>
<th>Error</th>
<th>The Great Fourfold Table of Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>False Negative (costly error)</td>
</tr>
<tr>
<td>2</td>
<td>Correct Failure.</td>
</tr>
</tbody>
</table>

**Prospect Theory: Why we don’t value gains vs. losses equally or consistently**

- Marginal value depends on location on the curve
  - Straight (yellow) line if marginal value was constant everywhere
- We invest more in avoiding a loss than in ensuring an equivalent win
- We don’t value complementary probabilities equally
  - 80% chance of survival vs. 20% chance of mortality
- Don’t value equivalent differences equally
  - $15 vs. $25 birthday cake vs. $435 vs. $445 tire
- Why ‘framing’ is crucial when establishing decision alternatives and goals

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**Our senses interact with our believing consciousness through our biased unconsciousness**

- “We form our beliefs for subjective, personal, emotional, and psychological reasons in the environments created by family, friends, colleagues, culture, and society”
- “We defend, justify, and rationalize these with intellectual reasons, cogent arguments, and rational explanations”

Beliefs naturally come first, explanations for beliefs naturally follow

Our brain is like most organizations. The CEO (consciousness) thinks they run things but the underlings (unconsciousness) who actually run things only let the CEO know some things and that’s mostly those things the CEO wants to hear.

**What are the most frequent veterinary medical errors? The unrecognized ones?**

- “There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don’t know. But there are also unknown unknowns. There are things we don’t know we don’t know.” Donald Rumsfeld, 2002
- Modified: There are known errors, but there are also unknown errors. There are errors we don’t know we don’t know.

“arrest of discovery is not ignorance—it is the illusion of knowledge.”
Ali Bosrst, 1984

**Illusion of Understanding (Fluency): Why can’t we explain as much or to the depth that we think we can?**

- Intuition provides us simplified, often good enough analyses, causing ‘illusions of understanding’
- “Illusion of fluency” arises when we confuse our familiarity or recognition with understanding
- We overlook complexity by failing to recognize it or by over-simplifying it
- We fail to distinguish between readily accessible knowledge (or in the heads of others) and that which is actually in our heads

“My success is . . . due to how I deal with not knowing . . . it’s dealing with what one doesn’t know that’s more effective than knowing.”
Ray Dalio, Bridgewater Associates, 2015

**Andrea diSessa Coin Test of Causal Model Intuition**

Place two identical coins having reeded edges (quarters, dimes) into contact on a flat surface
Maintaining the contact, roll the top coin around the edge of the bottom coin until it is directly beneath it (halfway around)
Will the way will the images be facing?
- a) Opposite direction
- b) Same direction

Take home:
1. We observe objects rolling on flat surfaces all the time, which trains our intuition
2. Not having observed many objects rolling on curved surfaces, we incorrectly apply the causal model we learned from flat surfaces
Interactionist Theory vs. Intellectualist Theory of Reasoning:

Conventional intellectualist view of reasoning:
• Reasoning evolved as a means to improve individual cognition for arriving at better beliefs and decisions for ourselves by ourselves
• Theory doesn’t explain flaws such as serious cognitive biases and lack of balance

Emerging interactionist view of reasoning:
• Reasoning evolved primarily as a tool to facilitate social interaction
• We are biased toward finding reasons supporting our view point because:
  • Goal is to justify our actions and to convince others to share our beliefs
  • Presenting reasons that undermine this support is counterproductive
• We are more demanding and objective in evaluating other’s reasons than in producing our own to:
  • Avoid being deceived by poor or fallacious arguments into accepting false ideas
  • Be justified in revising our beliefs when presented with sound reasons for change

How to Have a Good Day: Harness the power of behavioral science to transform your working life
• Author was organizational behavior consultant for McKinsey for 15 yrs
• Three memes:
  • The two-system brain
  • The discover-defend axis
  • The mind-body loop

Start with Why: How great leaders inspire everyone to take action, Simon Sinek
• TEDTalk
• The answer to protocol drift?

https://www.ted.com/talks/simon_sinek_how_great_leaders_inspire_action

The Question: How do we restructure current processes to take advantage of our natural reasoning structure?

Back to the 1969 Bovine Practitioner

Strong feelings were demonstrated when the ego of certain speakers was deflated by challenges to their remarks. Such demonstrations are useful in that problems are more clearly defined.
Reduce the likelihood of poor discussion outcomes by applying established ground rules?

Philosophers have established principles for effective argumentation amongst themselves, such as:

- Rapaport’s Rules (Principle of Charity)
  - First state the opposing position so clearly, vividly and fairly that your opposition agrees that you understand it
  - List any points of agreement
  - Mention anything you’ve learned from the opposition
  - Only then do you state your position, rebuttal or criticism
- Occam’s Razor (law of parsimony)
- Occam’s Broom cannot be used
- Inconvenient facts cannot be swept under the rug

The common goal is to develop agreement (dialectic), not for one side to win over the other (debate)

Three potential starting points for guidance from the professional arguers (philosophers) and from others:

Aviation learns from Near Misses: July, San Francisco

- NOTAM - 28L closed for evening repair work
- PIC ~ 20,000 hrs, 4,797 in type
- Copilot ~ 10,000 hrs, 2,300 in type
- Pilots flying for 5 hours, landing at 4 AM their time
- FMS bridge visual approach
- ‘Dog leg’ for noise abatement
- Not over ILS
- Throttled up at 150’ over taxiway for go around, descended to 59’
- 3 wide bodies - 2 787’s and an A340 - and 1 737 on taxiway
- 787 tailfin is 55.5’, A340 tailfin is 56.5’, A380 tailfin is 79’
- Now only ILS approaches when a parallel runway is closed

Our brain fools us: Cockpit perspective when landing on parallel runways at night, approximating what the two pilots ‘saw’

Final pragmatic point: Strong decision-making processes reduce error

- Decisive (2013) is an excellent book on general decision making processes
- The authors address four villains and how to combat them:
  - Narrow framing
  - Confirmation bias
  - Short-term emotion
  - Overconfidence
- Significant point: When a group is making a major decision and the group is unanimous, someone must play the role of devil's advocate
  - If no opposition to a decision has been uncovered and considered, chances are good people haven’t looked hard enough yet

Take homes:

- Veterinary medical error rates approximate those in human medicine
- We error because we are human, making error elimination difficult if not impossible
- Reducing error requires more focus on systems than on the individual
- Working memory capacity and dual processing have important roles in error
- Checklists reduce errors by:
  - Reducing the effect of distractions on completing sequential steps of routine tasks
  - Mitigating the mind-numbing effect of severe stress in crises
- We are no longer regarded as having the potential to be solo perfect reasoners
- Our reasoning is naturally biased toward improving our social interaction
- A question is how to adapt our processes to this new paradigm
- The ‘Illusion of Explanatory Depth’ likely plays a role in unknown error
- We need to use good argumentation rules when delving into contentious topics
“Let’s be careful out there”

Hill Street Blues’ Sergeant Esterhaus’s roll call close (Michael Conrad)

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