Medical Error: Knowing (and herding) the Elephants

50th AABP Annual Conference
Sept 14-16, 2017
Omaha, Nebraska

John Gay, DVM PhD DACVPVM
Asso, Professor of Epidemiology
Veterinary Clinical Sciences
Washington State University
Pullman, WA

The Evolution of Bovine Practice

Two physicians planted medical error ‘mindbugs’

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

http://www.epi.umn.edu/cvdepi/

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

Coined the term "evidence-based medicine"

Ubiquitous human error, its occurrence, its effects and its prevention, is addressed by many in various forums

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

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

Dr. Prineas’s evidence of problems with common practices

Tonsillectomy Study (Pseudodoxia Pediatrica NEJM 232:691)

389 11 yr old children with tonsillitis

Examined by physicians

214 (55%) Tonsillectomy not Recommended

174 (45%) Tonsillectomy Recommended

Sneaky Epidemiologists

Examined by other MD’s

(Blind to previous exam results)

What do you think the other MD’s recommended?

214 (55%) Tonsillectomy Not Recommended

Examined by other MD’s

115 (54%) Tonsillectomy not Recommended

99 (46%) Tonsillectomy Recommended

Epidemiologists couldn’t believe results

What do you think the next MD’s recommended?

Doing it over again
And again

115 (54%) Tonsillectomy Not Recommended

64 (56%) Tonsillectomy Recommended

51 (44%) Tonsillectomy Recommended

\[ \text{Coin Flip!} \]

What like this is happening in animal health?

If we haven’t looked, we don’t know!

Dr. Eddy’s JAMA essay on medical decision problems

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

- 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

umo: With the farm as another level of system level, veterinarians deal with systems of more complexity with even less support

Evidence of process problems continued

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

- Cardiologists using high quality angiograms to evaluate coronary vessel stenosis:
  - ...estimating if greater than half, disagreed on 60% of patients
  - ...on rereading the same image, changed their minds 8% to 37% of the time, depending on the vessel segment
- Eddy’s Comment: Observers looking at the same thing will disagree with each other and with themselves from 10% to 50% of the time
- Not just a clinician’s problem
  - Expert pathologists disagreed (benign vs. malignant) on 38% of human skin melanoma biopsy specimens (Hum Pathol 27:528-31)

Admittedly, these are likely tough ones, not “slam dunks”

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 850,00 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?

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

Diagnostic error rate evidence from bovine medicine

The post-mortem examination in ruminants and its possible benefit to ruminant clinical medicine J Comp Path 156(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 (489)
  - Had bearing on death
  - 8% complete discrepancy (113)

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 mi 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

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 Certified 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

Piloting is unexpectedly exceptionally disorienting

J RR Stott Extreme Physiology & Medicine 2(2):2849-2856

- 85% of aviation accidents are due to pilot’s unrecognized disorientation
- On the ground, maintaining orientation is an unconscious proprioceptive activity
- Sitting in chair, standing up
- In flight, maintaining orientation requires conscious effort
  - Deceptive force environment > vestibular illusions
  - Loss of visual horizon (clouds, night) > instrument flight
- Sensory illusions from disorientation frequently have fatal outcomes
  - Graveyard spiral
  - Corollis illusion

Reason’s ‘Swiss Cheese’ accident causal chain

Example: Dana Air Flight 0992 accident report

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

For better or for worse, it’s because that is the way we’re wired!
How can we 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
- Solution: Check PubMed to see if the book author has a research publication record

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, if complex
- We naturally ‘chunk’ items to improve fit
  - Phone numbers and social security numbers into 3 blocks
- Familiarity increases ‘chunk’ size compared to unfamiliarity
  - e.g, rhp, dbc, sfb, hww, axo, src, aoe, aat, it is harder to process and remember than pnr, phd, cbs, flb, twa, sos, rca, uss, att
- Concept labels (memes) – diseases, procedures, ...
- The problem – Switching tasks requires resetting the conscious stage, 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 intelligence augmentation (Siri)?

Our reasoning functions as two systems, conscious and subconscious

- System I: Conscious Rider
- System II: Subconscious Elephant

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 investment</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, “gut feeling”</td>
<td>Rational, reasoning, logical</td>
</tr>
<tr>
<td>Implicit learning, trained by System II</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. Altered, 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:

According to a research at Cambridge University, it doesn't matter in what credit the letters in a word are, the only thing that is true is that the first and last letter are both right. The rest can be a total mess and you can still read it without porbelm. This is because the human mind does not read every letter by itself, but the word as a whole.

Given above and SpellCheck, one might wonder why we invest so much time in learning to spell. But it 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 'Davis Cambridge jumbled letters'.

Dual-process is also impacts communication effectiveness

- External Environment
- Speaker’s Subconscious Elephant
- Speaker’s Conscious Rider
- Recipient’s Subconscious Elephant
- Recipient’s Conscious Rider

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

Why is human reasoning like playing pool on a table with a warped (biased) slate?

- Nature wired biases into our brains
- Knowledge of these biases does not significantly reduce their effect
- That requires using processes designed to minimize the opportunity for each
- Example: collective application of the scientific method and process
- Published RBCT’s

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

Multiple cognitive biases may be involved in 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

Optical illusions illustrate the ‘education role’ of System II and the dominance of System I

“My Wife and My Mother-in-Law”
WE Hill, Puck 6/11/1915
(also called the Boring Figure)

- Is it wife’s Ear or mother-in-law’s Eye?
- Is it wife’s Chin or mother-in-law’s Nose?
- Is it wife’s Necklace or mother-in-law’s Mouth
- The Point: Once System II educates System I as to what you see, System I makes it hard for System II to see something else

https://www.wikiquote.org/wiki/Wife_and_Mother-in-Law

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.

https://www.mrc-cbu.cam.ac.uk/people/matt.davis/cmabridge/
Error Mgmt Theory: Nature biased us toward the least costly reasoning error

<table>
<thead>
<tr>
<th>Error 1</th>
<th>Error 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>True World State</td>
<td>True World State</td>
</tr>
<tr>
<td>Snake Present</td>
<td>Snake Present</td>
</tr>
<tr>
<td>Snake Absent</td>
<td>Snake Absent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brain Sens</th>
<th>True World State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snake Present</td>
<td>Correct Detection</td>
</tr>
<tr>
<td>Snake Absent</td>
<td>False Negative (costly error)</td>
</tr>
</tbody>
</table>

The Great Fourfold Table of Life

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

- Marginal value is dependent on curve location
- Blue line if marginal value was constant everywhere
- We invest more in avoiding a loss than in assuring 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 important when establishing decision alternatives

Our biased senses interact with our believing consciousness through our 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.

If you are curious about your biases, an on-line test to assess them

Project Implicit

https://implicit.harvard.edu/implicit/

- “It is well known that people don’t always ‘speak their minds’, and it is suspected that people don’t always ‘know their minds’”
- “This web site presents a method that demonstrates the conscious-unconscious divergences much more convincingly than has been possible with previous methods”
- “The Implicit Association Test, or IAT for short”

What are the most frequent veterinary medical errors? Might they be unknown 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.

“The greatest obstacle to discovery is not ignorance—it is the illusion of knowledge.”

DJ Boarst, 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, coarse, often good enough analyses, causing illusions of understanding
- Illusion of fluency arises when we confuse 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.”

Andrea diSessa Coin Test of Causal Model Intuition

Place two identical coins having needed 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

Work at uncovering our IOED’s (Illusions of Explanatory Depth)

IOED occurs when:
• One’s mental model of the process is too simple, too abstract, or flat wrong
• We don’t understand the causal linkages well enough to describe how all of something works
To uncover one’s IOED’s for a complex problem, explain the causal chain to a depth of 5 why’s or so, noting one’s knowledge gaps
• Teach it to a group of sharp students
• Invest 10 minutes drawing out the causal web in front of a peer, having them ask questions
• Invest 30 minutes drawing out key causal linkages and then check a good textbook
Useful techniques to Google:
• ‘Feynman Technique’
• Toyota 5 Why’s

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 by ourselves
• Theory doesn’t explain flaws such as serious cognitive biases and lack of balance

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 do we get out of the muck?

Lumber wagon stuck in mud, Dawson, Yukon Territory, 1899

Emerging Interactionist Theory of Reasoning

New interactionist theory of reasoning has considerably more explanatory power than older theories:
• Explains the presence of confirmation bias in our reasoning
• Explains why we are more efficient at evaluating arguments than producing them
• Explains why in a social exchange our responses tend to be stronger than our statements
• Supports the wisdom of the complete scientific process and of the adversarial judicial process
• Supports working in pairs that trust but challenge each other

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

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 a poor outcome similar to that of the 1968 NMC meeting by establishing ground rules for productive dialectics

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)

Swapping of peer herd reviews?

- Note that much significant success occurs when people work for some time in pairs
- Swap herd reviews with colleagues in other areas
  - They review one or more of your better herds annually, in exchange you review one or more of their better herds annually
  - $1,500 (?) per herd annually?
- Motivation for herd participation is the opportunity to accelerate improvement
- Review problem areas to uncover any associated IOED’s, individual and profession
  - Items identified as IOED’s for everyone become research topics to generate new information through on-farm research by practitioners and academicians
- Professional association coordinates materials development, oversees swap bureau services and provides venue for discussions at annual meeting
  - Develop problem-focused and integrated materials, such as topic checklists
  - Use feedback from herd reviews to expand and improve materials

Normal cockpit perspective for night landing on SFO 28R with 28L closed

- 28L closed with lights off for that evening
- Pilots flying for 5 hours, landing at 4 AM their time
- FMS bridge visual approach
  - ‘Dog leg’ for noise abatement
  - Not on ILS
  - 3 wide bodies - 2 787’s and an A340 - and 1 737 were on taxiway
- Descended to 59'
- 787 tailfin is 55.5', A340 tailfin is 56.5', A380 tailfin is 79'

Cockpit perspective when landing on parallel runways at night, approximating what the pilots ‘saw’

Pragmatic view: 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, someone must play the role of devil’s advocate if the group is unanimous
- If no opposition to a decision has been uncovered and considered, chances are good people haven’t looked hard enough yet
### Take home points:

- Veterinary medical error rates appear similar to those in human medicine
- We error because we are human, making further error reduction very difficult
- Reducing error requires more focus on the system as well as 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 to improve 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 error
- We should establish argumentation rules before delving into contentious topics

---

**“Let’s be careful out there”**

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

jmgay@wsu.edu

http://people.vetmed.wsu.edu/jmgay/courses/