Medical Error:
Knowing (and herding) the Elephants

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

John Gay, DVM PhD DACVPM
Assoc. Professor of Epidemiology
Veterinary Clinical Sciences
Washington State University
Pullman, WA

“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)

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

Two physicians planted my ‘MindBugs’ on medical error

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

Coined the term “evidence-based medicine”
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)

Doing it over again

214 (55%) Tonsillectomy Not Recommended

Examined by other MDs

115 (54%) Tonsillectomy not Recommended

99 (46%) Tonsillectomy Recommended

Even the epidemiologists couldn’t believe results

Examined by other MD’s (Blind to previous exam results)
And again

115 (54%) Tonsillectomy Not Recommended

64 (56%) Tonsillectomy Recommended

51 (44%) Tonsillectomy Recommended

Tonsil removal was a Coin Flip!

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!

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?
- ‘MindBugs’ 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 1° 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) (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, 51’ 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

Much of his work is on-line as pdfs
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
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!

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
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

https://human-factors.arc.nasa.gov/organization/personnel_view.php?personnel_id=36

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
  - onp, rph, dbv, dfb, icb, sso, sib, rus, aat, t is harder to process and remember than o npr, phd, bvd, fbi, cbs, sos, ibr, 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 II
Conscious Rider

Subconscious Choice!

System I
Subconscious Elephant

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><em>The massive Elephant</em></td>
<td><em>The small Rider</em></td>
</tr>
<tr>
<td>Adaptive unconscious</td>
<td><strong>Conscious self</strong> (where we ‘live’)</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, “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. 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:

Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mtttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt thng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can stll raed it wouthit porblem. Tih is bcuseae the huamn mnid deos not raed ervey ltteer by istlef, but the wrod as a wlohe.

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

By the way, there is more to this meme than is represented above - Google ‘Davis Cambridge jumbled letters’

https://www.mrc-cbu.cam.ac.uk/people/matt.davis/cmabridge/

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

Fig 1 Dual-process model of reasoning applied to diagnosis. Adapted with permission from Croskerry P. Context is everything or how could I have been that stupid? Healthcare Q. 2009; 12:e171-6.


http://dx.doi.org/10.1016/j.cppeds.2013.07.003
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.

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
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

If you remember nothing else from today, remember ★★

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?

https://www.linkedin.com/pulse/cognitive-bias-cheat-sheet-simplified-buster-benson
Error Mgmt Theory: Nature biased us toward the least costly reasoning error

<table>
<thead>
<tr>
<th>Brain-Sensed World State</th>
<th>Snake Avoidance</th>
<th>True World State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snake Present</td>
<td>Snake Present</td>
<td>Correct Detection</td>
</tr>
<tr>
<td>Snake Absent</td>
<td>Snake Absent</td>
<td>False Negative (costly error)</td>
</tr>
<tr>
<td>Correct Detection</td>
<td>False Positive (cheap error)</td>
<td></td>
</tr>
<tr>
<td>Correct Rejection</td>
<td></td>
<td></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 depends on location on the curve
  - Straight (yellow) 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 ≠ 20% chance of mortality
- Don’t value equivalent differences equally
  - $15 vs. $25 birthday cake ≠ $435 vs. $445 tire
- Why ‘framing’ is crucial when establishing decision alternatives and goals
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.

Project Implicit
https://implicit.harvard.edu/implicit/

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.

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

DJ Boorstin, 1984

https://en.wikiquotes.org/wiki/Donald_Rumsfeld
https://quoteinvestigator.com/tag/daniel-j-boorstin/
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 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
How do we reduce future potential for error?

Lumber wagon stuck in mud, Dawson, Yukon Territory, 1899
https://commons.wikimedia.org

Warning:
My "Crystal" Ball is a Brunswick

Improve people management by improving our understanding of emerging behavioral science

How to Have a Good Day: Harness the power of behavioral science to transform your working life
- Author was organizational behavior consultant for McKenize 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
Work at uncovering our IOED’s (Illusions of Explanatory Depth)

IOED occurs when:

- Our 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 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, encouraging them to critique it
- Invest 30 minutes drawing out key causal linkages and then verify with a good textbook

Useful techniques to Google:

- ‘Feynman Technique’
- ‘Toyota 5 Why’s’

Interactionist Theory of Reasoning: Opportunity?

New interactionist theory of reasoning has considerably more explanatory power than older theories:

- Explains why confirmation bias occurs 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?
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

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:

- Intuition Pumps and Other Tools for Thinking by Daniel C. Dennett
- The 7 Habits of Highly Effective People by Stephen R. Covey
- What Philosophy Can Do by Gary Gutting
**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

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

[Image]

https://www.ntsb.gov/investigations/Pages/DCA17IA148.aspx
https://thepointsguy.com/2017/07/sfo-near-miss/

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

[Image]

http://cockpitviewlandingvideos.aircraftpaintingschemes.com/images/929.jpg
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)

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