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Navigating the Path from Diagnostic Errors to Diagnostic Excellence for Dangerous Vascular Diseases in the ED

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Johns Hopkins Medicine & Bloomberg School of Public Health

Diagnostic Excellence – Disclosures for Dr. Newman-Toker

1. **Grant & Contract Support…**
   - **US Federal Grants & Contracts**: NIH (NIDCD U01 DC013778, NINDS U01NS080824, NCATS U24 TR001609), AHRQ (R18 HS026640, R01HS27614, EPC 503-4262, R18 HS029350)
   - **US Foundation Grants & Contracts**: Gordon & Betty Moore Foundation, American Heart Association, Coverys Foundation, AARP, SIDM
   - **US Industry Grants & Contracts**: Natus-Otometrics
2. **Equipment Support (research video-oculography [VOG] devices)…**
   - Autronics-Interacoustics
   - Natus-Otometrics (licensing JHU decision support technology, related research grant as principal investigator)
3. **Inventor (diagnostic decision support tools)**
   - JHU decision support technology – algorithms to diagnose conditions using VOG
   - JHU US patent for mobile phone-based diagnosis (US patent #12,266,109 on 4/1/2025)
4. **Career focus on 'Diagnosis' (academic conflict of interest)…**
   - Past President / Former Board Member, Society to Improve Diagnosis in Medicine (SIDM) (unpaid)
   - Director, Johns Hopkins Armstrong Institute Center for Diagnostic Excellence (salary support for effort)

DISCUSSION INCLUDES OFF-LABEL USE OF VOG & MOBILE PHONES FOR STROKE DIAGNOSIS

Diagnostic Excellence – A Special Word of Thanks

1. Relevant Grant Support (2002-present)

- National Institutes of Health (NIDCD, NCRR/NCATS, NINDS)
- Agency for Healthcare Research & Quality
- Patient Centered Outcomes Research Institute
- Society to Improve Diagnosis in Medicine
- Kaiser Permanente / Johns Hopkins Medicine
- Gordon & Betty Moore Foundation
- Coverys Community Health Foundation, AARP, American Heart Association

2. Mentors, Trainees, & Collaborators (abridged list)

- David Zee, G.M. Halmagyi, Simmons Lessell, Dan Hanley, Justin McArthur, Steve Galetta, Marty Samuels, Barbara Vickrey, Fred Brancati, Lisa Heiser, Peter Pronovost, Allen Kachalia, David Hellman
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- Dan Gold, Jorge Kattah, Kevin Kerber, Joanna Jen, Rich Rothman, Yu-Hsiang Hsieh, Zheyu Wang, Daisy Zhu, Jonathan Edlow, Dana Siegal, Ketan Mane, Zack Berger, Kathy McDonald, Kathleen Sutcliffe, Elham Yousef, Matt Austin

Our DX Center Team – Diverse & Inclusive

Prologue: The Base Case

John Michael Night

The Tragic Story of John Michael Night's Misdiagnosis

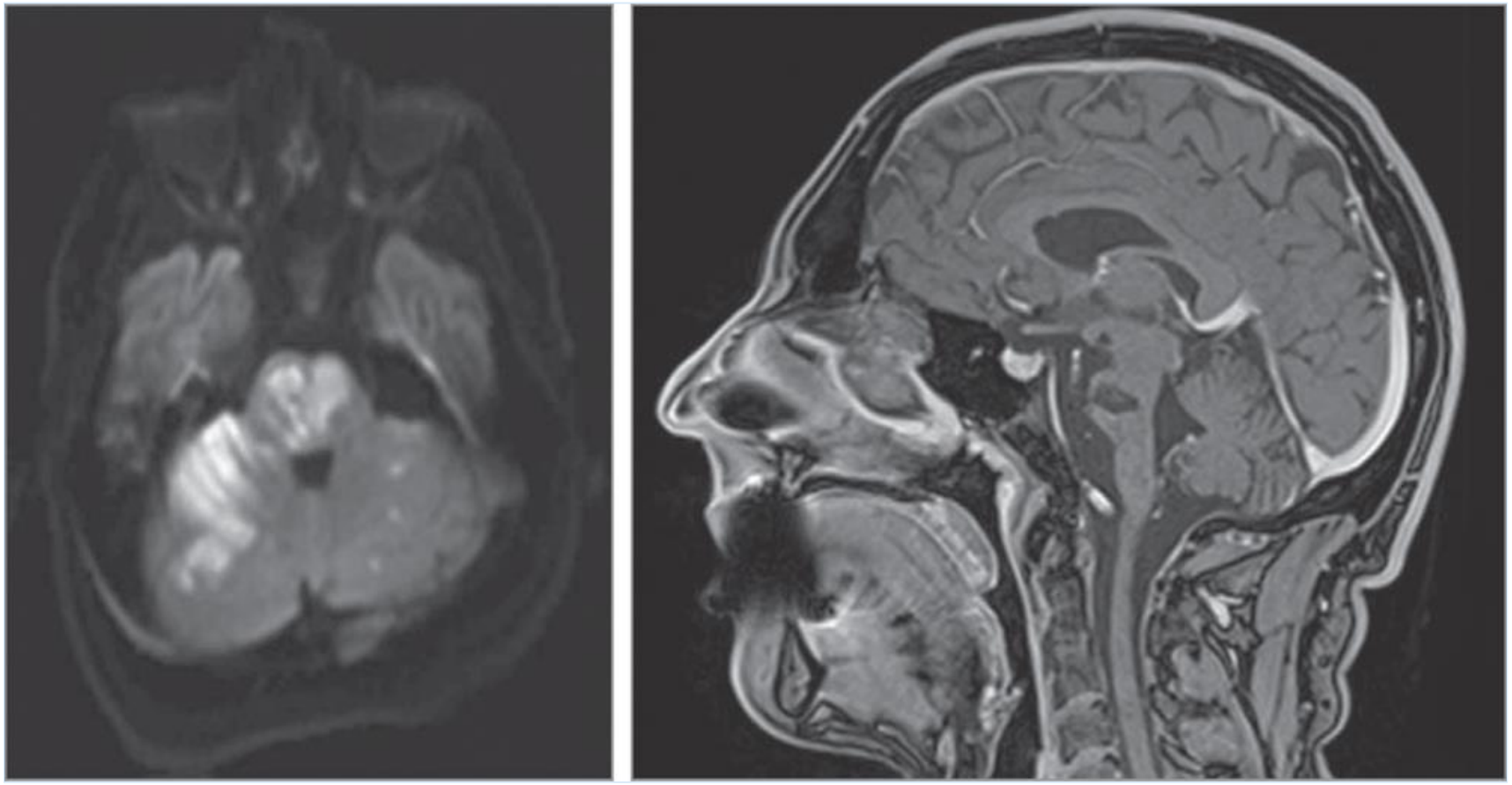
BASE CASE

- An 18-year-old star lacrosse player develops vertigo, vomiting, and unsteady walking two days after his final high school game.
- His parents are very worried (they note he is a highly trained athlete who is "never sick") and take him to the emergency department.
- The doctors aren't listening to his parents who are sure this is something serious and are instead focused on "common" causes.
- The doctors have not considered a key dangerous cause and have not been trained to look for the subtle but telltale red flag signs of…

Newman-Toker – Patient and Family Have Granted Permission to Share Their Story

Brainstem/Cerebellar Stroke from Basilar Occlusion

BASE CASE



Hocker & Wijdicks, JAMA Neurology 2015

Evolving Stroke Ending with Locked in Syndrome

BASE CASE

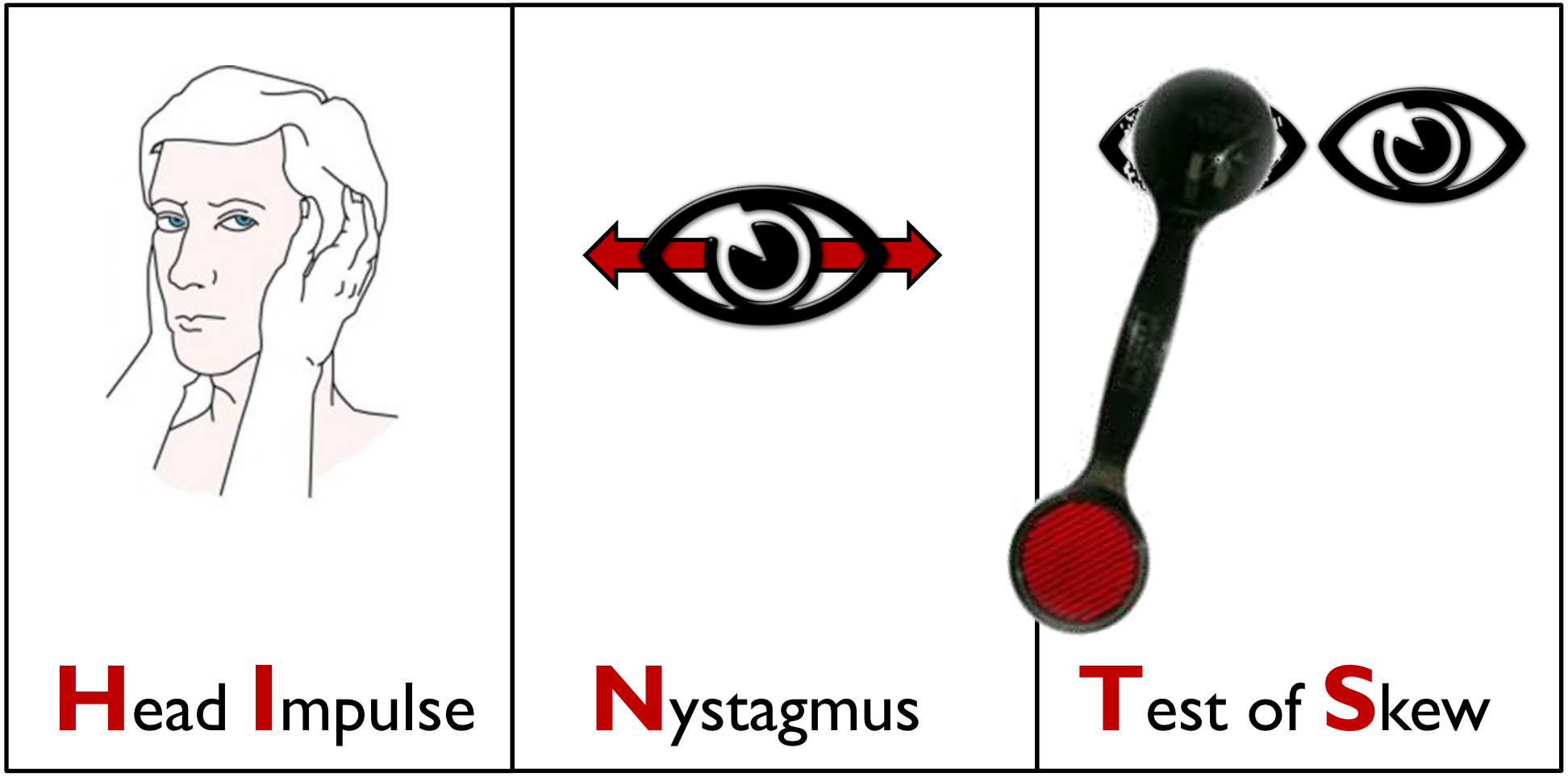
What happened after an early diagnosis was missed and treatment windows had passed.

What should have been if early eye movement diagnosis led to prompt clot-buster therapy.

Newman-Toker – Patient and Family Have Granted Permission to Share Their Story

Diagnostic Eye Findings – H.I.N.T.S.

BASE CASE



Kattah et al., Stroke 2009; Tarnutzer et al., Annals of Neurology 2023

Objectives & Outline

Diagnostic Errors – Learning Objectives

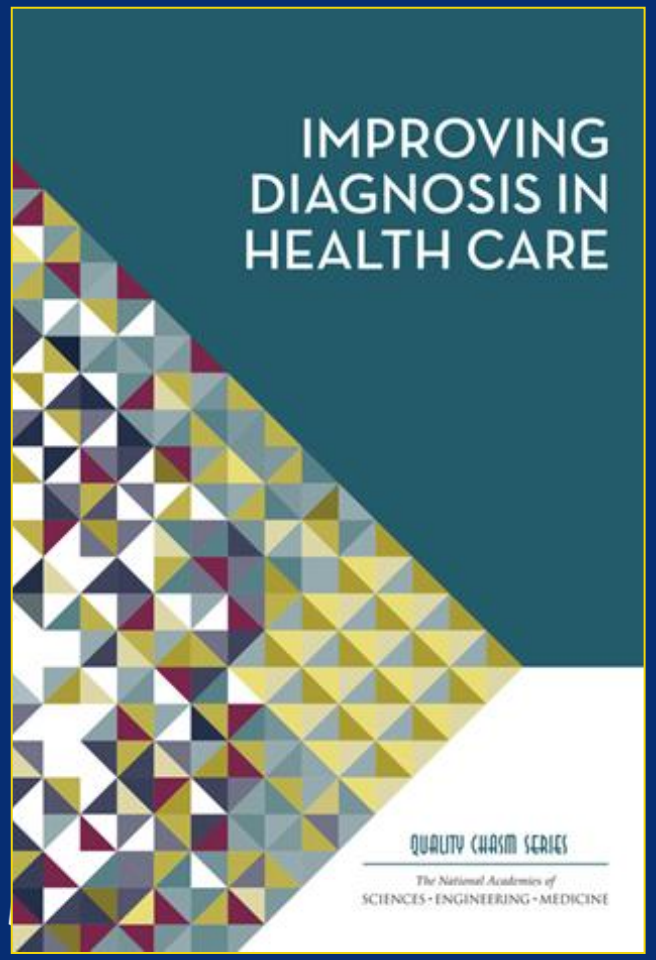
1. Summarize public health burden & financial impact of diagnostic errors and misdiagnosis-related harms in the US.
2. List common causes and prioritize targets for diagnostic error reduction and quality improvement initiatives in the ED.
3. Discuss solutions at provider, organizational, and system levels that can contribute to diagnostic excellence in the ED.

Diagnostic Excellence – Lecture Outline

1. Burden & Impact
2. Core Definitions
3. Common Causes
4. Cognitive Errors
5. Work System
6. Systems Solutions
7. Key Takeaways
8. Questions & Answers

Burden & Impact

Improving Diagnosis in Healthcare



"The delivery of healthcare has proceeded for decades with a blind spot: Diagnostic errors…"

"…most people will experience at least one diagnostic error in their lifetime, sometimes with devastating consequences."

"Improving the diagnostic process is not only possible, but it also represents a moral, professional, and public health imperative."

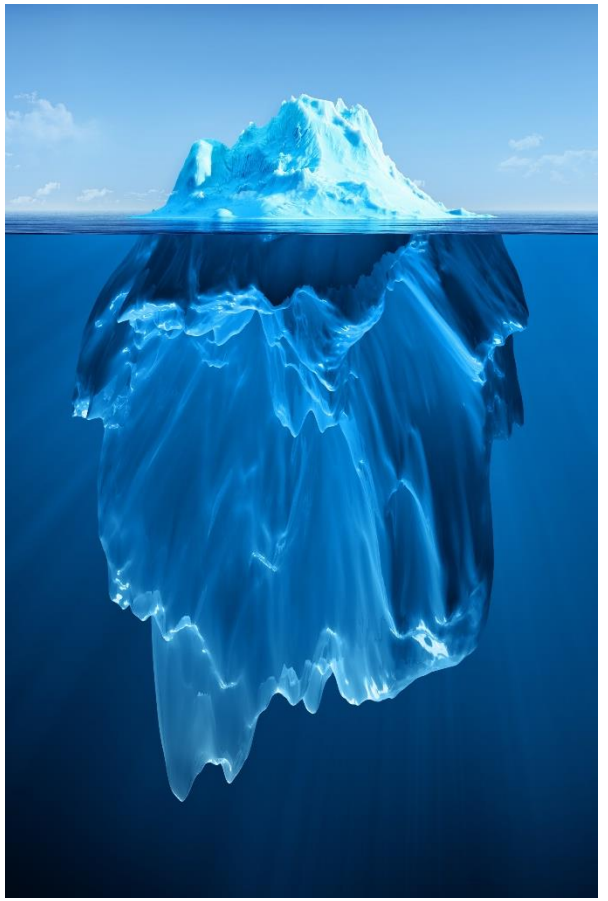
National Academy of Medicine, Improving Diagnosis in Healthcare 2015

Diagnostic Errors – Public Health Imperative

Most Common
Most Catastrophic
Most Costly

Diagnostic Errors
USA alone likely > 50 M/yr
Serious Harms 0.5-1.0 M/yr
Societal Cost > $200 B/yr
Waste est. $50-100 B/yr

All Other Errors Combined



Newman-Toker et al., DEM 2018; Newman-Toker et al., BMJQS 2023; Newman-Toker BMJQS 2025

Aggregate Diagnostic Error and Harm Estimates

Table 1 Estimated diagnostic errors and serious misdiagnosis-related harms by clinical setting in the USA annually*

Clinical setting	Visits (n)†	Diagnostic errors (n)‡	Serious harms (n)‡
Inpatient	34 million	~2.4 million (95% CI 1.6M to 3.3M)[9]	~376 000 (95% CI 185K to 566K)[9]§
Emergency department	140 million	~7.2 million (95% CI 5.0M to 11.2M)[11]	~433 000 (95% CI 266K to 1062K)[11]
Primary care clinics	521 million	~32.8 million (95% CI 31.9M to 33.7M)[13]	~231 000 (speculative)[2]
Specialty care clinics	515 million	~10–30 million (speculative)	~114 000 (speculative)[2]
All visits combined	1.2 billion	~50–100+ million (speculative)¶	~909 000 (PR 684K to 1170K)**

Annual US Diagnostic Errors

All Settings: ~~50-100 million

EDs: ~7.2 million *(95% CI 5.0-11.2)*

Annual Misdiagnosis-related Harms

All Settings: ~0.9 million *(PR 0.7-1.2)*

EDs: ~0.4 million *(95% CI 0.3-1.1)*

Newman-Toker, BMJ Quality & Safety 2025

Diagnostic Errors – "Big Three" Causes of Serious Harm

Vascular

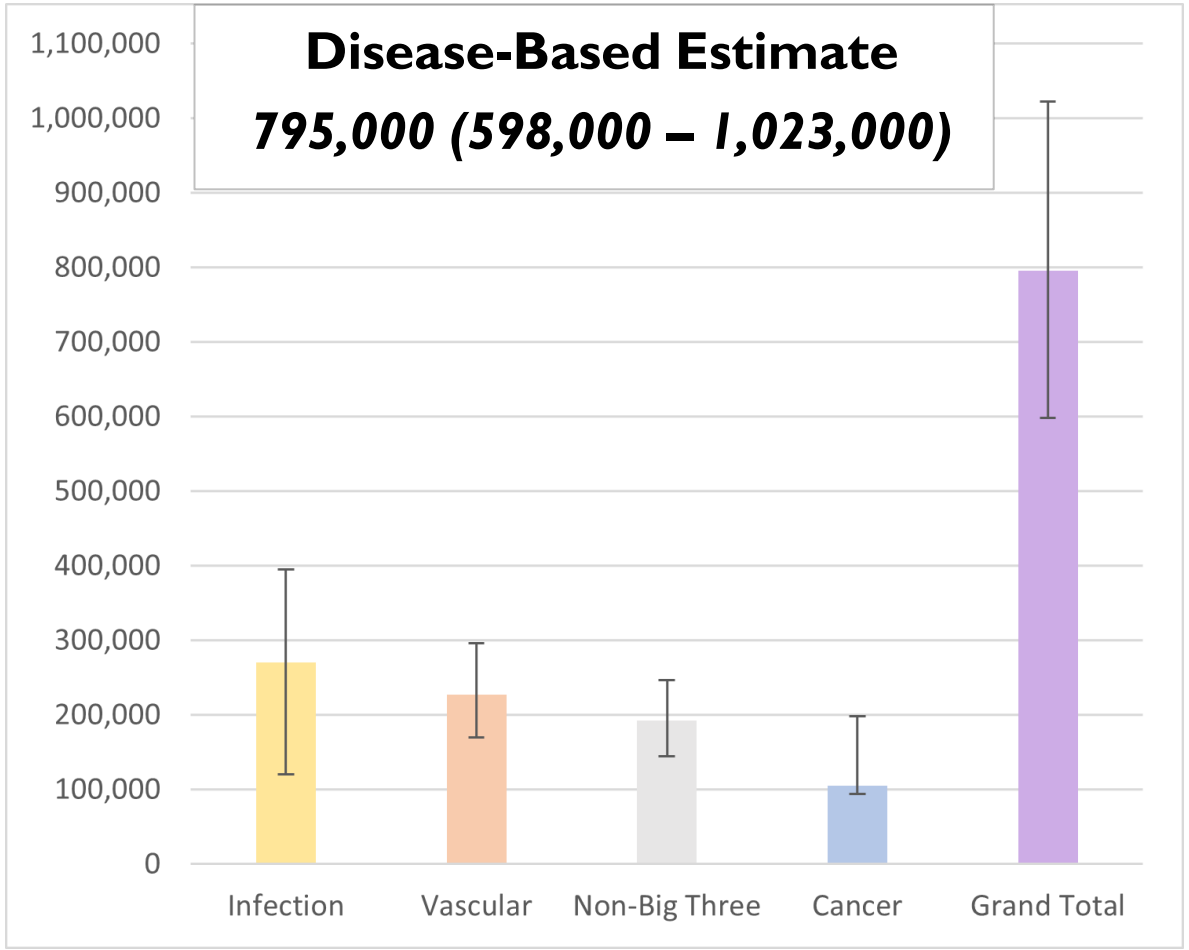
Infection

Cancer

Our prior work showed that the "Big Three" account for 75% of serious harms in both malpractice claims & clinical studies of diagnostic error.

Newman-Toker et al., Diagnosis (Berl.) 2018

Total Serious Misdiagnosis-Related Harms in the U.S. per Year



Serious Harms ~795,000/yr

- ~425,000 disabilities
- ~370,000 deaths

Serious Harms Breakdown

- 34% Infection – 271,000
- 29% Vascular – 228,000
- 24% Non-Big 3 – 192,000
- 13% Cancer – 105,000

N.B. – Data are for U.S. in 2014; current estimate is ~909,000

Newman-Toker et al., BMJ Quality & Safety 2023; Newman-Toker, BMJ Quality & Safety 2025

‘Top 15’ Diseases Leading to Serious Harms when Missed

‘Top 5’ shown below from each ‘Big 3’ Category

These 15 diseases account for ~50% of serious harms

Just 5 diseases account for ~39%

VASCULAR
1 Stroke
4 Venous Thromboembolism
Arterial Thromboembolism
Aortic Aneurysm & Dissection
Myocardial Infarction

INFECTION
2 Sepsis
3 Pneumonia
Meningitis & Encephalitis
Spinal Abscess
Endocarditis
Appendicitis (#6 all ages)

CANCER
5 Lung Cancer
Breast Cancer
Colorectal Cancer
Melanoma
Prostate Cancer

Newman-Toker et al., Diagnosis (Berl.) 2018; Diagnosis (Berl.) 2019; BMJ Quality & Safety 2023

Diseases List Causing High-Severity Harms

Table 4. Proportion of misdiagnosis-related harms attributable to "Big Three" diseases reported in ED malpractice claims, broken down by high-severity versus low-/medium-severity harms*

Category	Condition (Diseases Grouped by "Big Three" Categories and Total Harms Broken Down by Organ System)	High-Severity Harm* Cases - % of Total (n)	Low-/Medium-Severity Harm* Cases - % of Total (n)
Big Three Disease Category Breakdown	**Big Three† (subtotal)**	**72.0% (952)**	**38.4% (365)**
	Vascular events	***41.5% (549)***	***10.9% (104)***
	Stroke	*13.5% (179)*	*3.4% (32)*
	Myocardial infarction	*8.3% (110)*	*2.7% (26)*
	Aortic aneurysm/dissection	*6.1% (81)*	*0.5% (5)*
	Venous thromboembolism	*5.1% (68)*	*1.4% (13)*
	Arterial thromboembolism	*2.8% (37)*	*0.7% (7)*
	OTHER vascular events	*5.6% (74) (each ≤ 2.2%)*	*2.2% (21)*
	Infections	***22.5% (298)***	***25.6% (243)***
	Meningitis/encephalitis	*4.7% (62)*	*0.9% (9)*
	Sepsis	*4.7% (62)*	*0.8% (8)*
	Spinal & intracranial abscess	*2.6% (34)*	*0.3% (3)*
	Pneumonia	*2.1% (28)*	*1.6% (15)*
	Necrotizing fasciitis	*1.2% (16)*	*0.5% (5)*
	OTHER infections	*7.3% (96) (each ≤ 1.0%)*	*21.4% (203)*
	Cancers	***7.9% (105)***	***1.9% (18)***
	Lung cancer	*3.9% (51)*	*0.5% (5)*
	OTHER cancers	*4.1% (54) (each ≤ 0.8%)*	*1.4% (13)*
	Non-Big Three† (subtotal)	**28.0% (371)**	**61.6% (585)**
	Trauma	***11.3% (149)***	***33.8% (321)***
	Other	***16.8% (222)***	***27.8% (264)***
	TOTAL HARMS	**100% (1,323)**	**100% (950)**
Major Organ System Breakdown	**Top 5 Organ Systems**	**78.6% (1040)**	**45.1% (428)**
	Neurologic (including stroke)	*34.1% (451)*	*14.9% (142)*
	Cardiovascular (not including stroke)	*22.8% (302)*	*6.1% (58)*
	Pulmonary	*7.6% (100)*	*3.1% (29)*
	Gastrointestinal	*7.1% (94)*	*18.8% (179)*
	Hematologic (including VTE)	*7.0% (93)*	*2.1% (20)*
	All Other Organ Systems‡	**21.4% (283)**	**54.9% (522)**
	TOTAL HARMS	**100% (1,323)**	**100% (950)**

VTE = venous thromboembolism

* Data sources and definitions are the same as in Table 3.

† The "Big Three" diseases refer to vascular events, infections, and cancers, which, together, account for approximately three-fourths of all serious misdiagnosis-related harms in malpractice claims (Newman-Toker et al., 2019).[17]

‡ The top "other" organ system was musculoskeletal/joints, accounting for 3.5% (n=46/1,323) of high-severity harms and 25.7% (n=244/250) of low-/medium-severity harms. Note that craniospinal fractures with neurological injury are listed as "neurologic."

42% vascular
23% infection

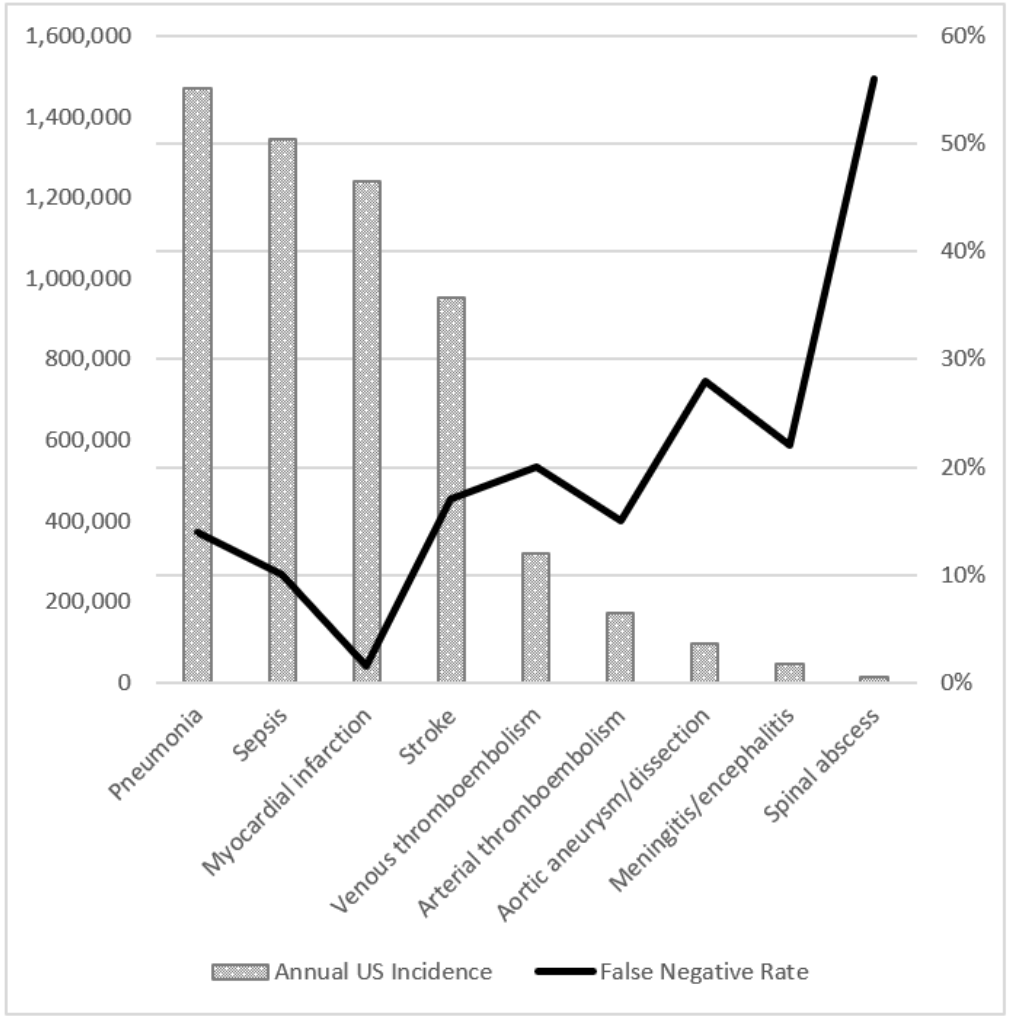
#1 Stroke
#2 Heart attack
#3 Aortic (AA/AD)
#4 Cord compression
#5 Pulm. embolus

Neurologic #1 organ system (34% of high-severity harms)

Newman-Toker et al., AHRQ 2022

Incidence & Rate of ED Errors/Harms

Error rates inversely related to population disease incidence



Overall Rates

- Dx Error ~5%
- Dx Adv. event ~2%
- Serious harm ~0.3%

Harms ~370,000

- >100,000 disabilities
- >250,000 deaths

Newman-Toker et al., AHRQ 2022

Delayed Diagnosis of DVT & PE

12.4% initially missed in ED

Table 1
Symptom that Each Patient Reported as the Main Reason Prompting Their Visit to the ED

First Symptom	ED Diagnosis (*n*)	Delayed Diagnosis (*n*)
Dyspnea	59	1
Substernal chest pain only	10	2
Pleuritic chest pain only	27	6
Substernal and pleuritic chest pain	12	0
Cough	2	1
Leg pain	10	0
Dizziness	4	3
Syncope	2	2
Confusion/abnormal behavior	0	1
Other	15	4
Total	141	20

Table 2
Comparison of Variables Hypothesized to Differ between Groups

Variable	ED Diagnosis (*n* = 141)		Delayed Diagnosis (*n* = 20)		p-value
Age (yr), mean (SD)	51	(17)	61	(15)	<0.001
Duration of symptoms* before ED (hr), mean (SD)	92	(101)	99	(89)	0.42
Altered mental status at diagnosis† (%)	11	(8)	6	(30)	0.009
Prior cardiopulmonary disease* (%)	33	(23)	5	(25)	0.54
Adverse outcome in hospital‡ (%)	12	(8.5)	6	(30)	0.01

Kline et al., Acad Emerg Med 2007

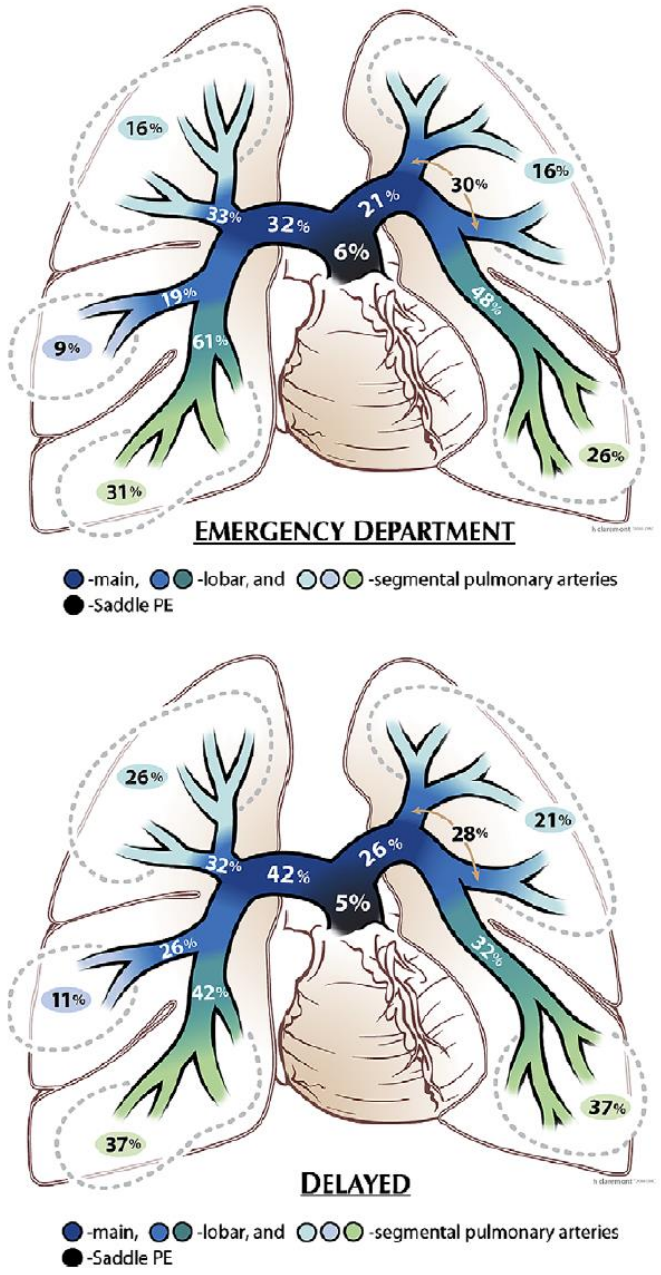


Figure 2. Location of emboli within the pulmonary vasculature for the two study groups. (Top) ED diagnosis group: pa-

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Atypical Presentations
**** CC dyspnea 42% vs. 5%***
**** Altered MS 8% vs. 30%***

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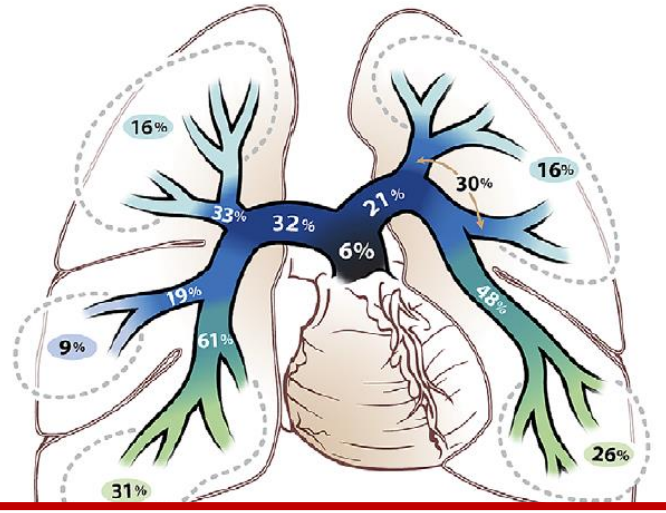
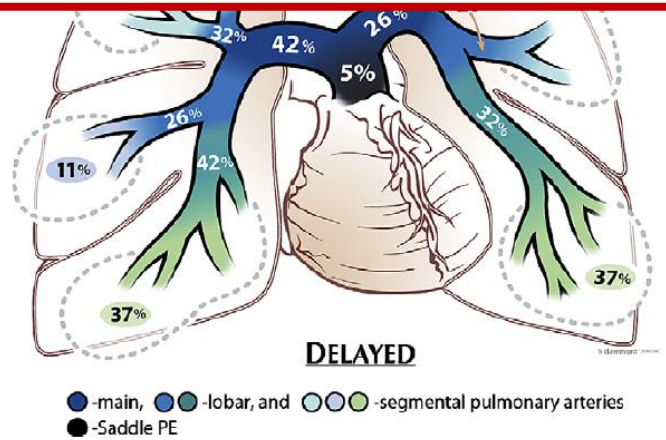
Adverse Outcomes
9% vs. 30%

Kline et al., Acad Emerg Med 2007



No Difference Seen in Pathophysiology or Disease Severity



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Top Serious Harm is Missed Stroke

BASE CASE

- #1 harm overall across clinical settings (also #1 harm in emergency department)
- Missed initially: stroke (~17%) vs. heart attack (~1.5%) [>10x]
- Estimated ~200,000 missed strokes/TIAs per year
- Estimated ~100,000 harmed by missed opportunity
- Risks rise precipitously with subtler/less obvious ("atypical") cases
  - **Wrong patient group** (**18-45yo** vs. >75yo) [**OR 7**]
  - **Milder** (subarachnoid hemorrhage without vs. with altered mental status) [OR 7]
  - **Transient** (transient ischemic attack [TIA] vs. completed stroke) [OR 11]
  - **Non-specific** (**DIZZINESS / VERTIGO** vs. motor) [**OR 14**]

Tarnutzer et al., Neurology 2017; Newman-Toker et al., AHRQ 2022; BMJ Quality & Safety 2023

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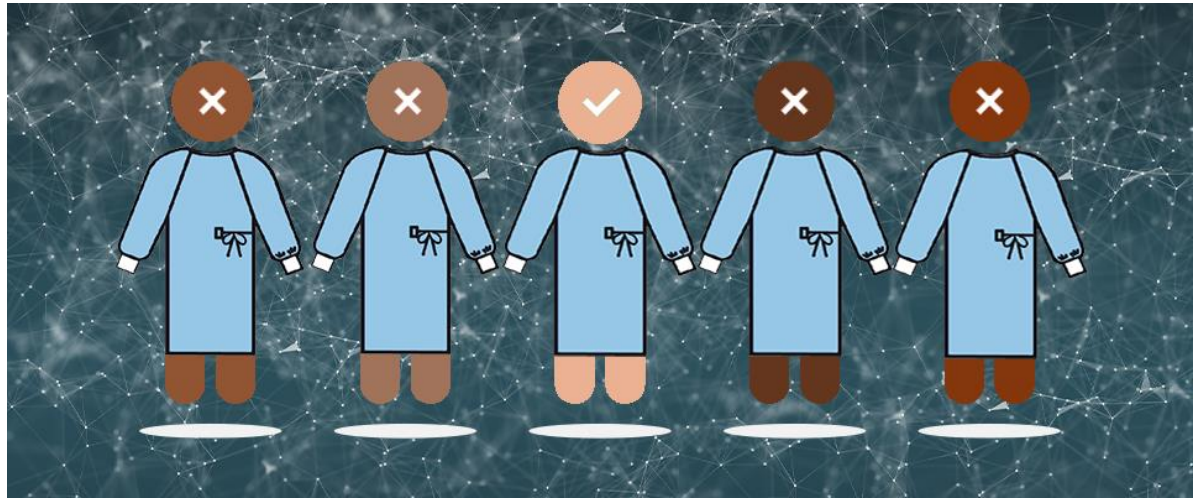
GIVEN THESE FACTORS, J.M.N. HAD A 95% CHANCE OF BEING MISDIAGNOSED

Diagnostic Errors – Disparities for People of Color

Black vs. Non-Hispanic White



Increased **Risk of Being Missed**

- **Stroke – +18%** (*Newman-Toker, 2014*)
  - Sepsis – +21% (*Nassery, 2021*)
  - Heart attack – +30% (*Sharp, 2021*)

Increased **Risk of Not Being Tested**

- **Stroke / CT or MRI – +11%** (*Kim, 2011*)
  - **Stroke / MRI – +17%** (*Kim, 2011*)

THE ONLY THING WORSE… FOR J.M.N. TO HAVE BEEN A WOMAN OR MINORITY

Core Definitions

Diagnostic Errors – NAM Definition

DIAGNOSTIC ERROR is the failure to…

- establish an accurate and timely explanation of the patient's health problem(s)

or

- communicate that explanation to the patient

National Academy of Medicine (NAM), Improving Diagnosis in Healthcare, 2015

Diagnostic Errors – Related Definitions

- **Missed Opportunity**

  …a failure to make a correct or timely diagnosis resulting from a preventable process failure (omission or commission), given the evolving context at the time, linked to the sociotechnical work system *(adapted from Singh, 2014)*

- **Misdiagnosis-related Harm**

  …harm resulting from the delay or failure to treat a condition actually present (when the working diagnosis was wrong or unknown) or from treatment provided for a condition not actually present. *(adapted from Newman-Toker, 2009)*

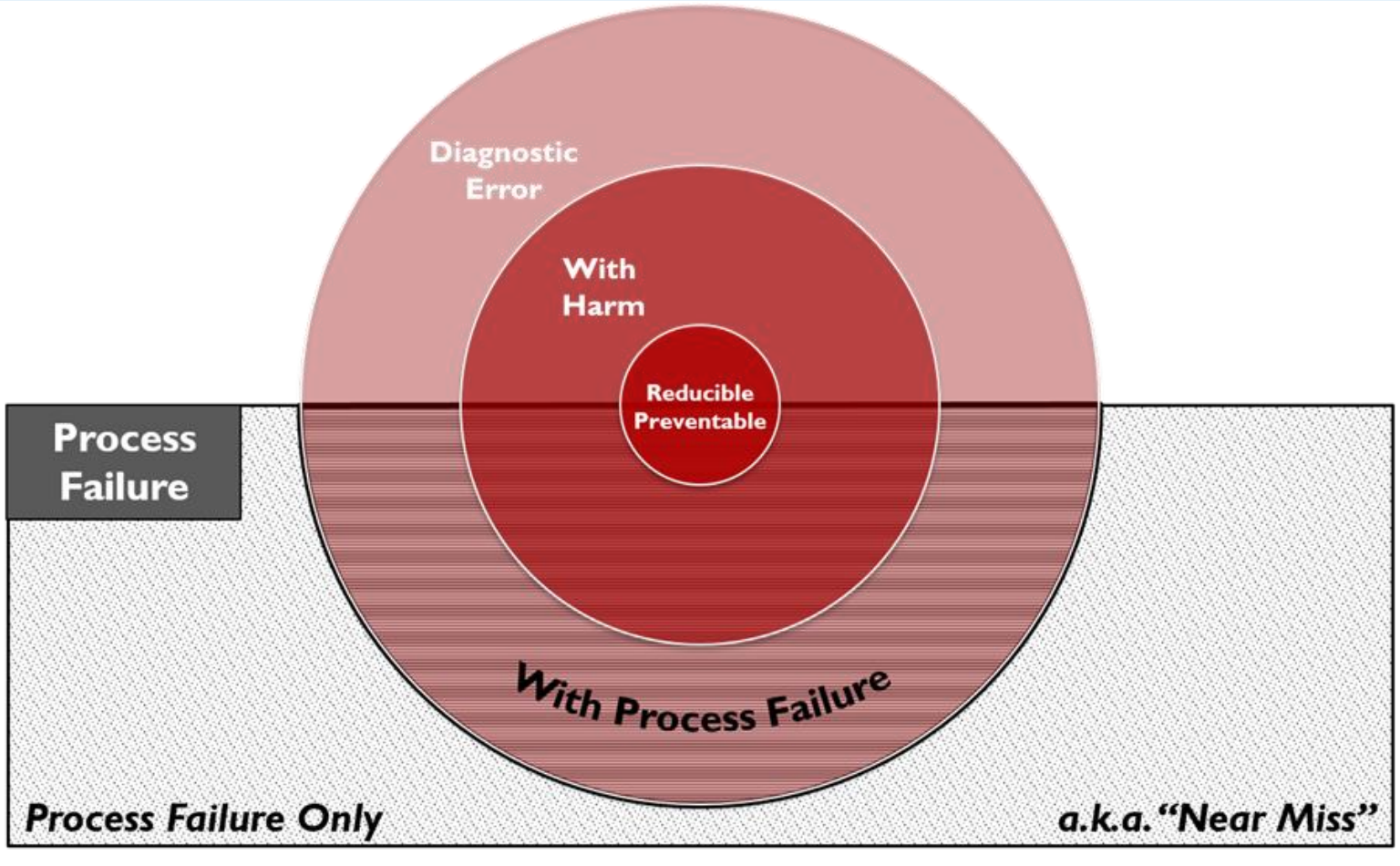
Singh et al., The Joint Comm. J. on Quality & Patient Safety 2014; Newman-Toker & Pronovost, JAMA 2009

Missed Diagnosis/Treatment Opportunities for Stroke

BASE CASE

- **Evolving basilar occlusion** – thrombolysis (intravenous [<4.5 hr] or intra-arterial [4.5-6+ hr])
- **Large cerebellar stroke or hemorrhage** – ICU monitoring with intraventricular catheter or posterior fossa decompression if clinical state worsens
- **TIA or minor stroke** – early secondary prevention, especially in high-risk vascular lesions or atrial fibrillation (aspirin, heparin, or warfarin)

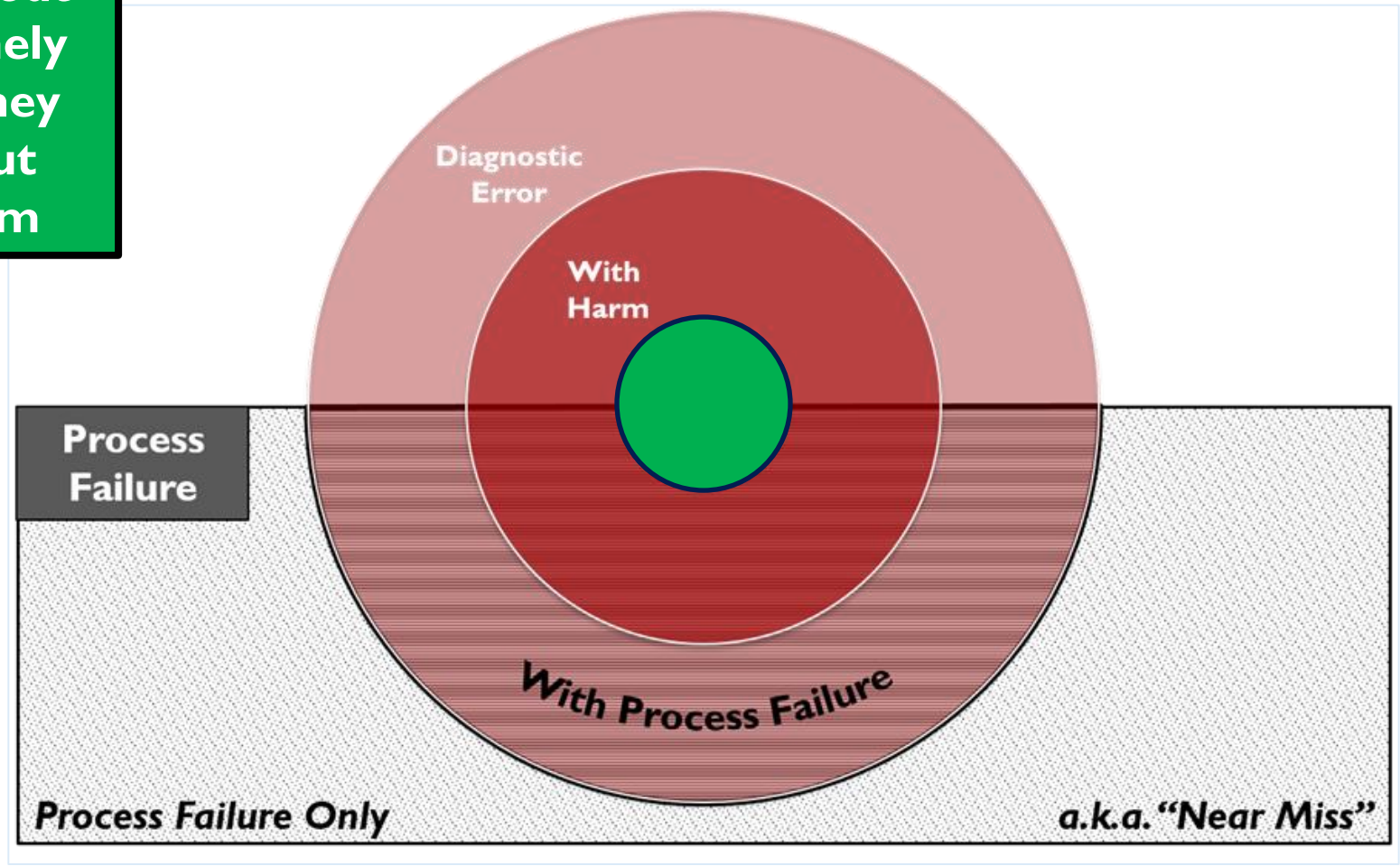
Diagnostic Errors – Summary of Definitions



Newman-Toker

Diagnostic Errors – Summary of Definitions

Patients care about an accurate, timely diagnosis, but they care most about preventing harm



Newman-Toker

Common Causes

Diagnostic Error RCA – Fishbone

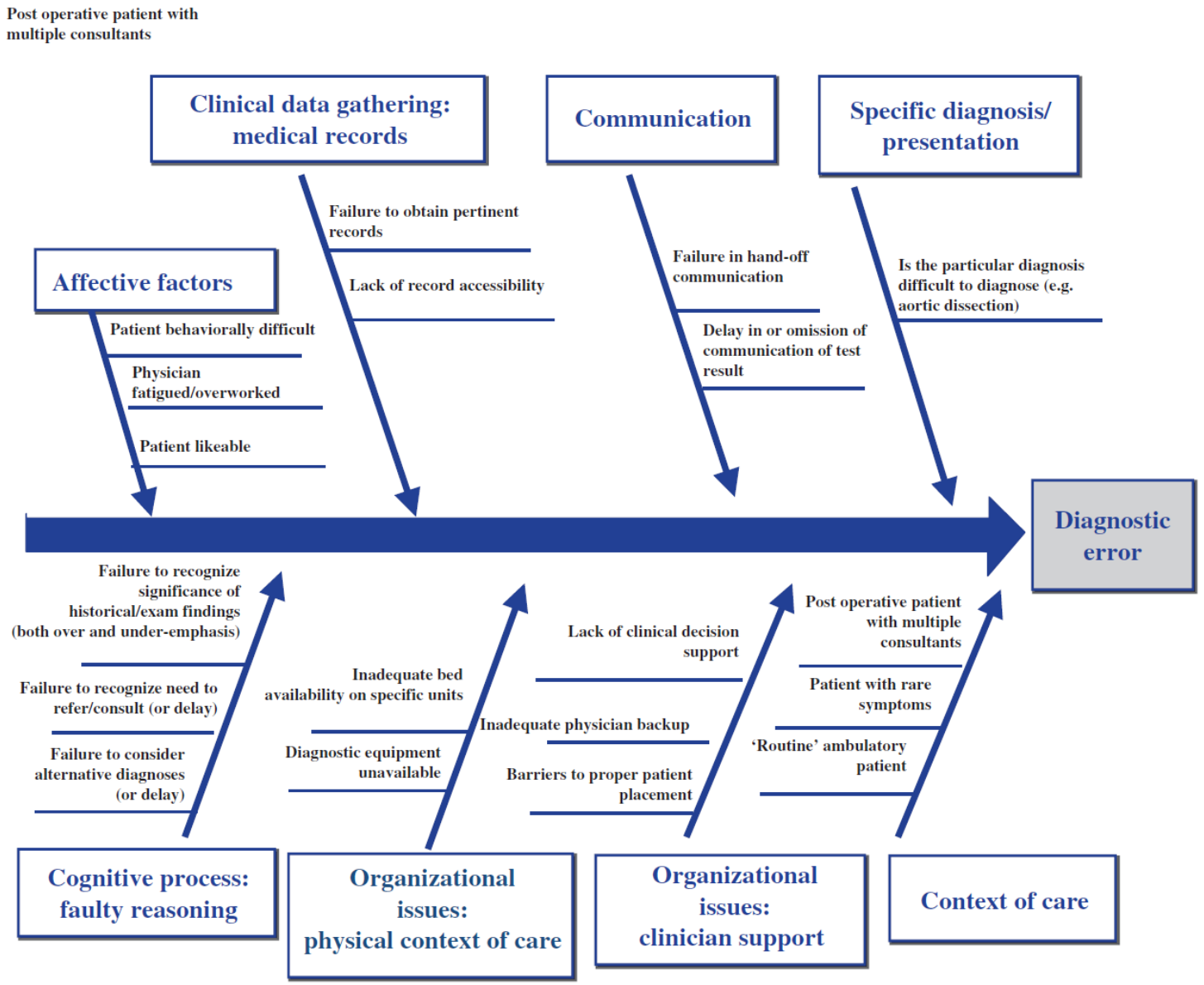
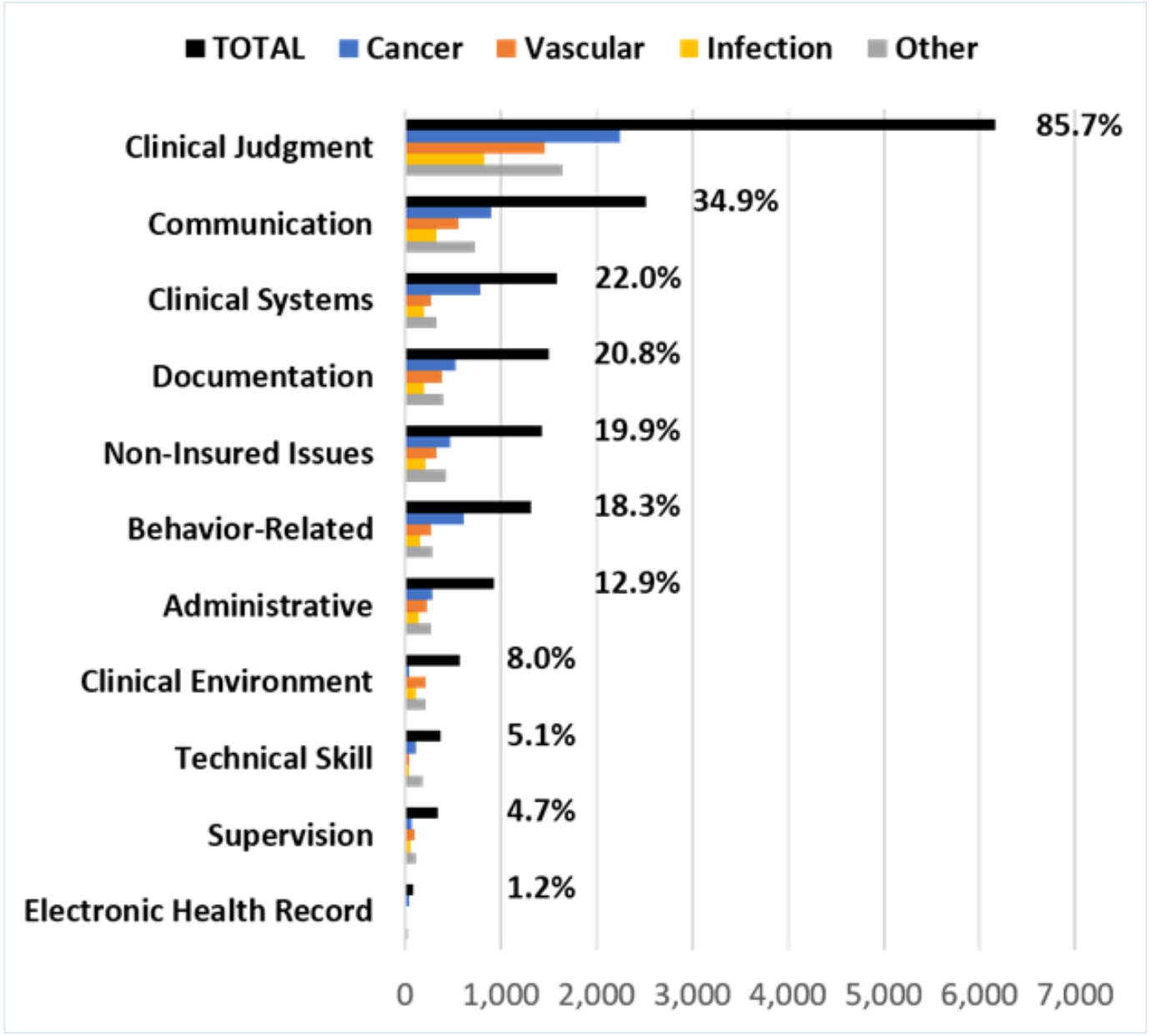


Figure 1 Diagnostic error fishbone framework in use at Maine Medical Center.

Reilly et al., Diagnosis 2014

Top Causes of Diagnostic Errors

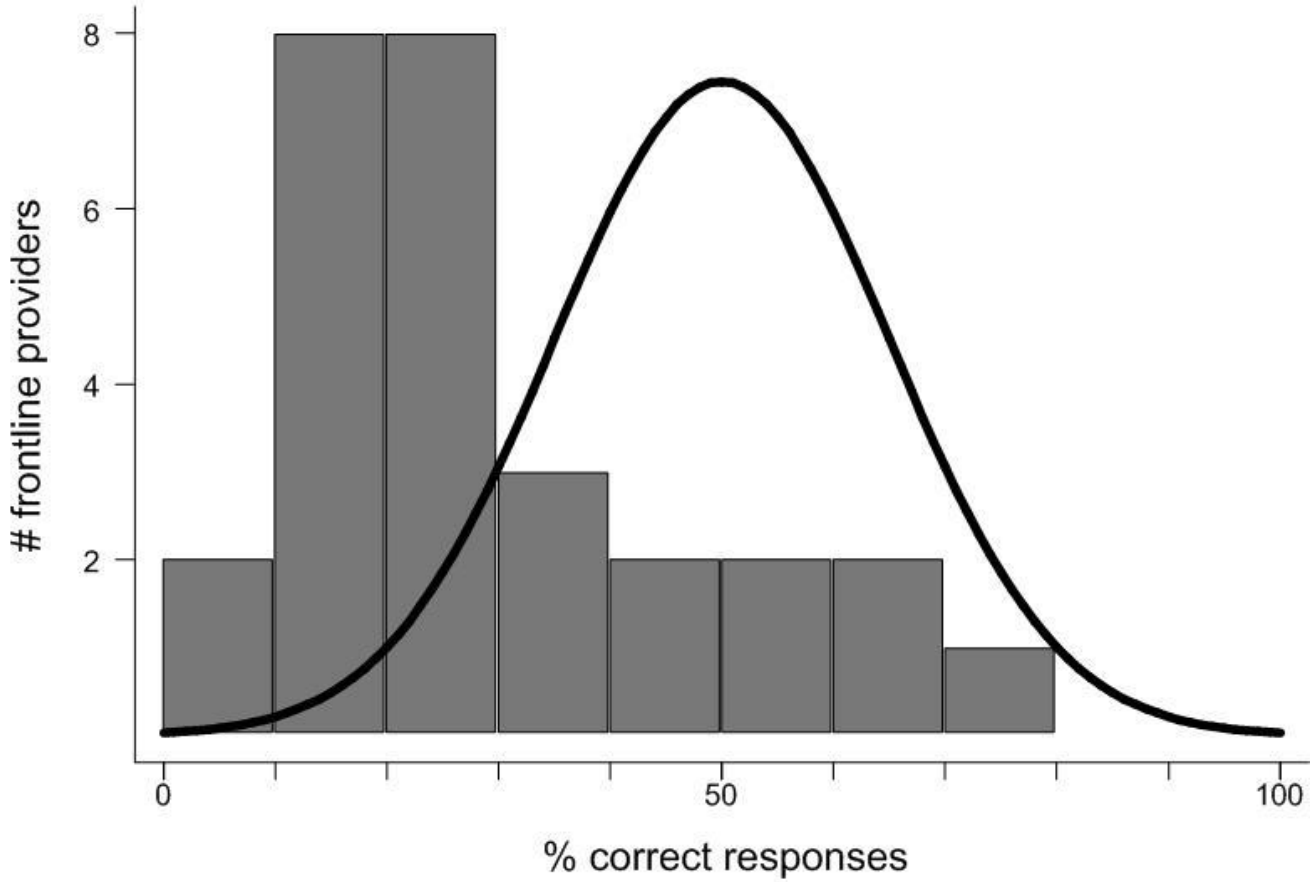


Newman-Toker et al., Diagnosis (Berl.) 2019

Misconceptions are Common in the Frontlines

BASE CASE

10-Q T/F Quiz for 28 ED/PCPs



Newman-Toker et al., Acta Otolaryngol 2008

Misconceptions are Common in the Frontlines

BASE CASE

MISCONCEPTIONS ⟵ CHANCE ⟶ UNDERSTANDING

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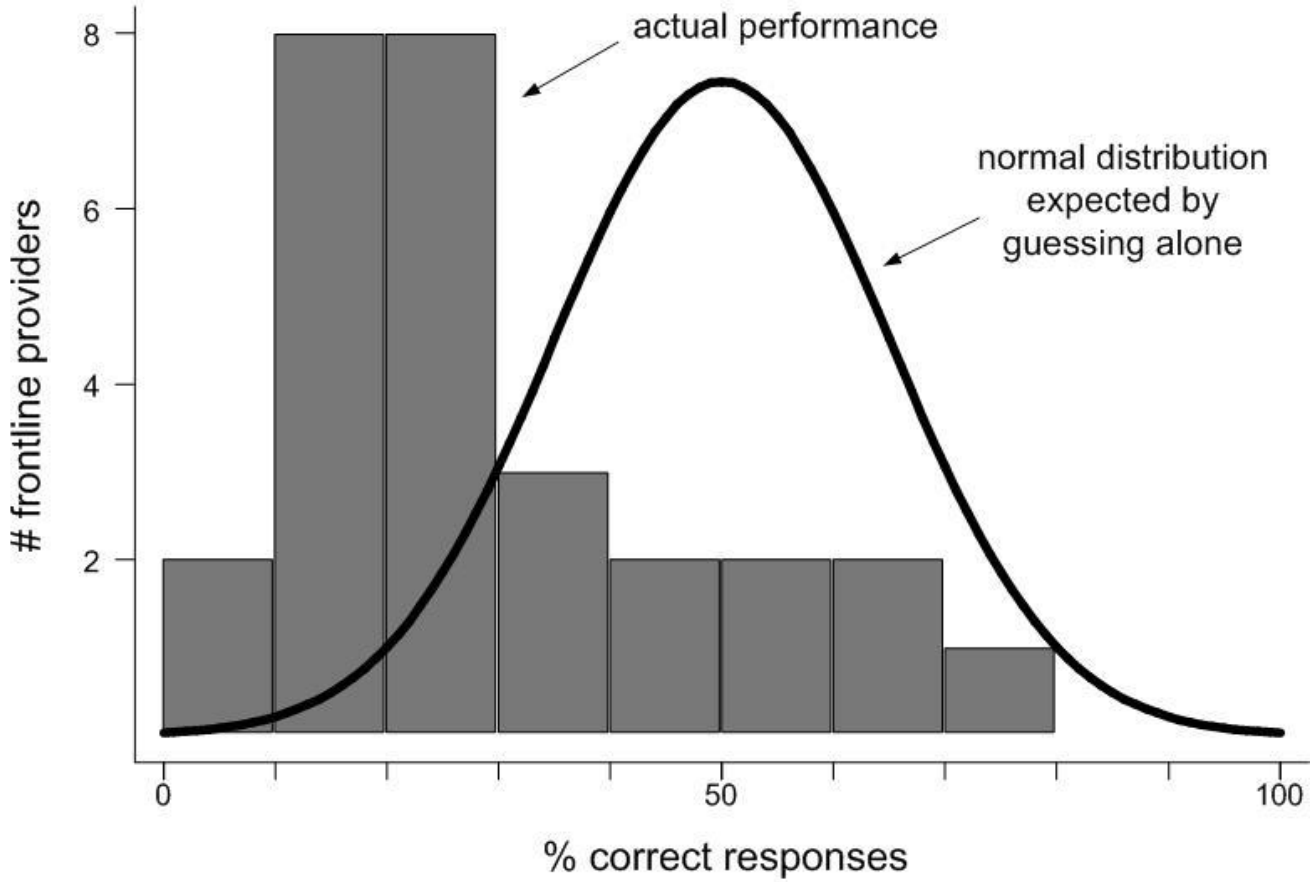


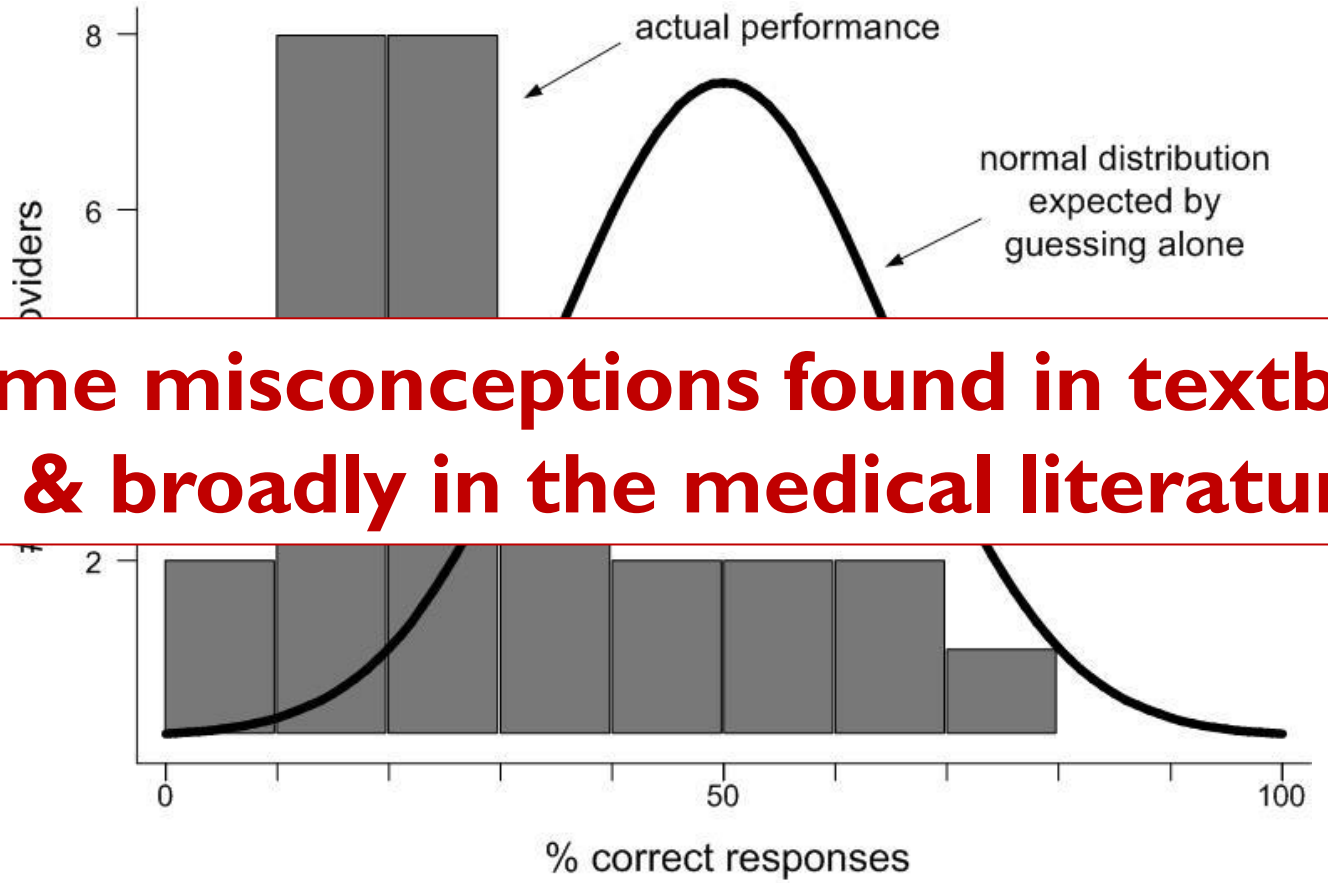
Newman-Toker et al., Acta Otolaryngol 2008

Misconceptions are Common in the Frontlines

BASE CASE

MISCONCEPTIONS ⟵ CHANCE ⟶ UNDERSTANDING

10-Q T/F Quiz for 2 ED/PCPs



Same misconceptions found in textbooks & broadly in the medical literature

Newman-Toker et al., Acta Otolaryngol 2008

Cognitive Errors

"Systems" vs. "Cognitive" Errors

Adapted from Graber, DEM 2011 (base art Tim Parish 2008)

Diagnostic Errors – Two Dominant Theories re: Cognitive Causes

COGNITIVE BIAS

Debiasing & Timeouts

EXPERTISE GAPS

The Four T's

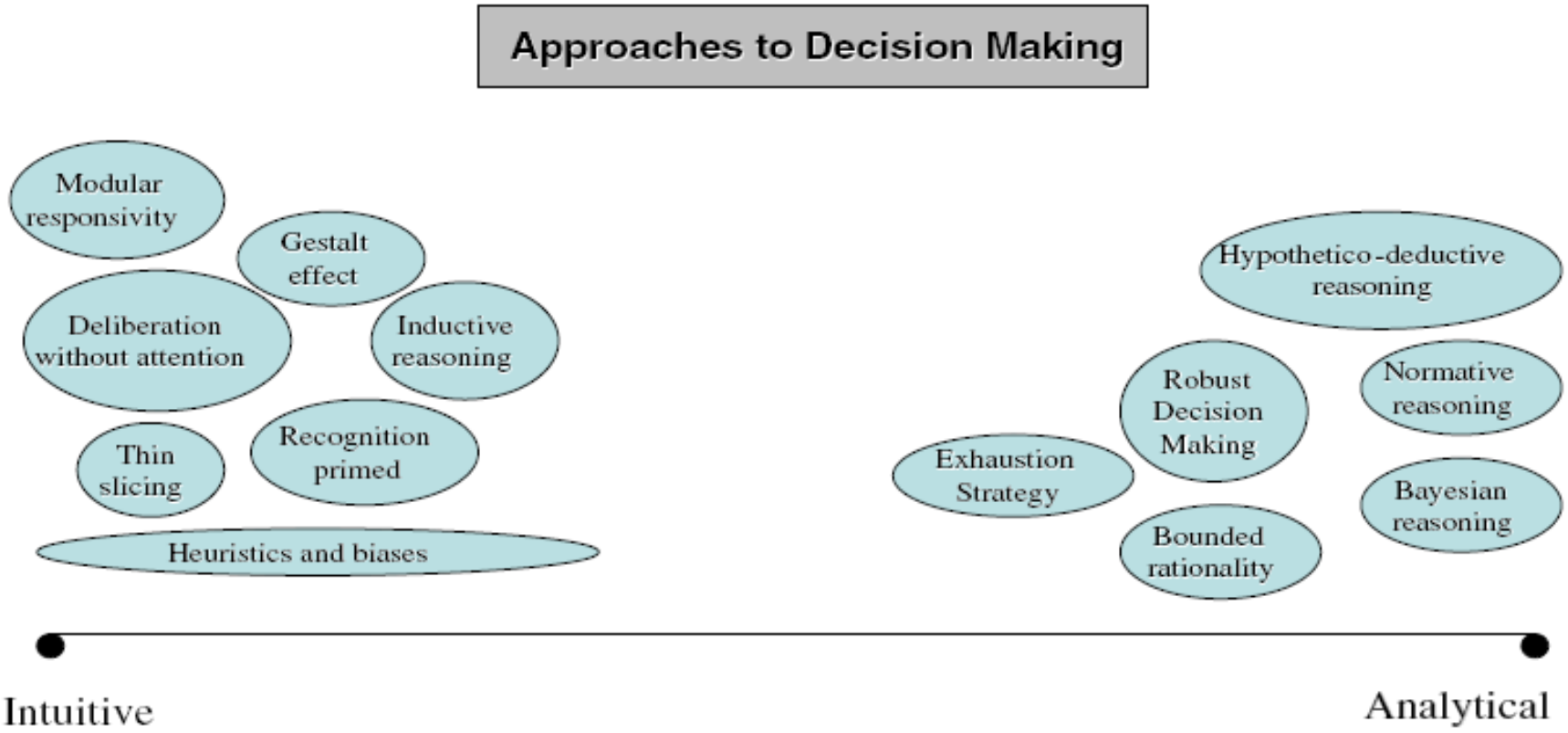
Team, Train, Tech, Tune

Cognitive Bias

Intuitive vs. Analytical Strategies

Clinical cognition and diagnostic error: applications of a dual process model of reasoning

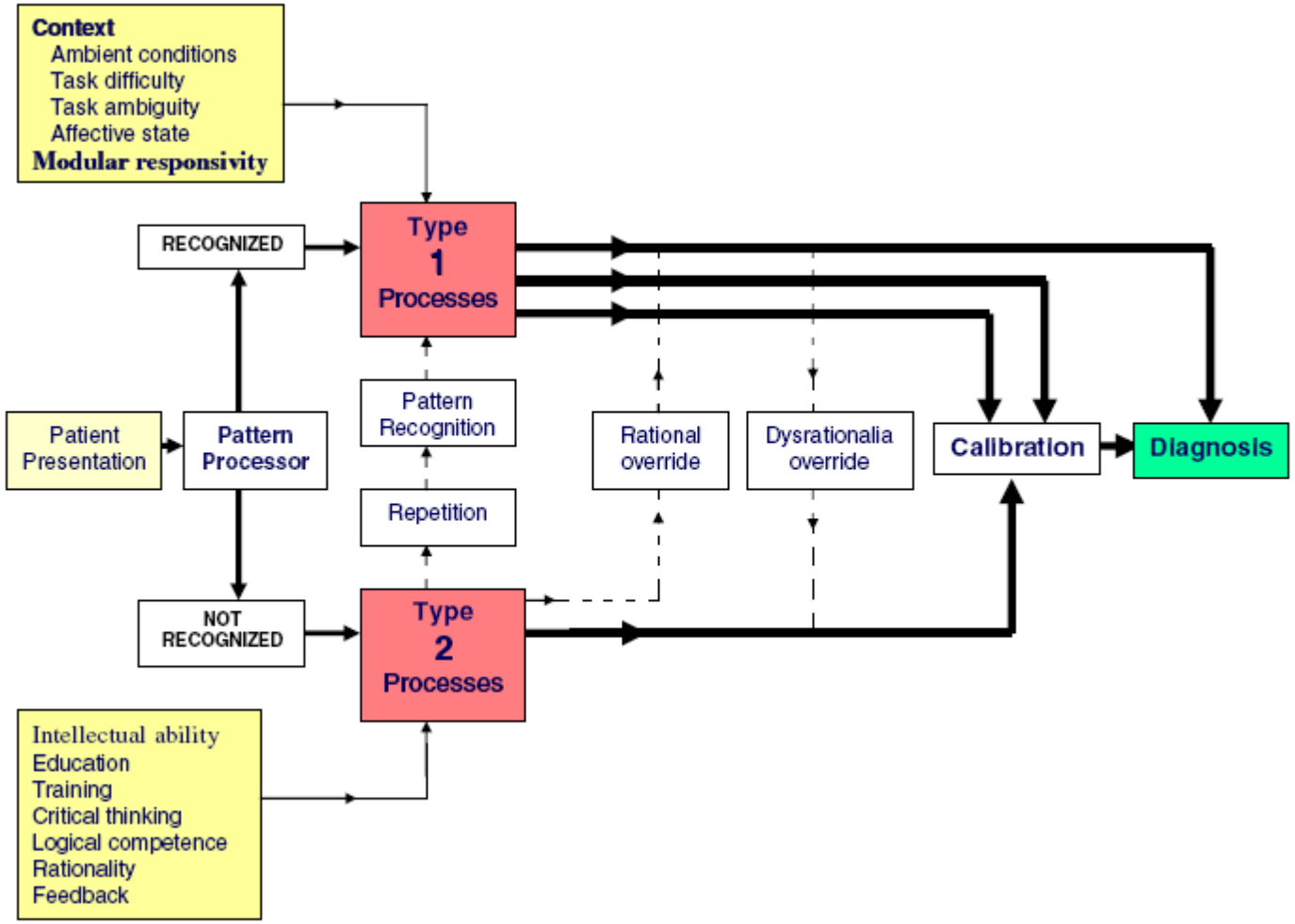
Pat Croskerry



Croskerry, Adv Health Sci Educ Theory Pract 2009

Dual Process Model of Cognition

Clinical cognition and diagnostic error: applications of a dual process model of reasoning



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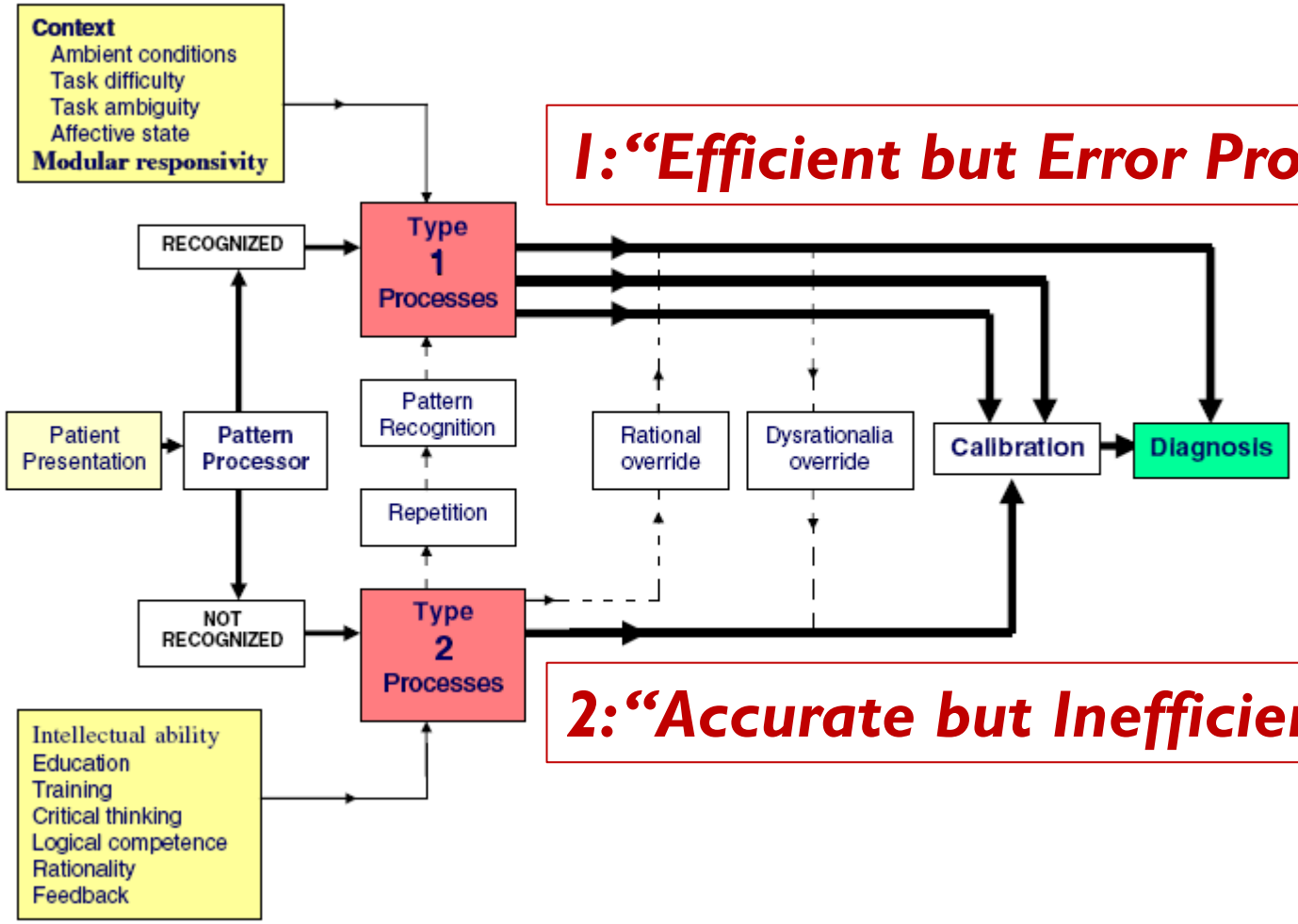

1:"Efficient but Error Prone"

2:"Accurate but Inefficient"

Croskerry, Adv Health Sci Educ Theory Pract 2009

Cognitive Heuristics & Biases

HEURISTIC OR PHENOMENON	PITFALL	CORRECTIVE STRATEGIES	CLINICAL MAXIMS	ILLUSTRATIVE STUDIES
Framing Effects:	Being swayed by subtle wording to focus on certain aspects of a case more than others	Examine case from alternative perspectives and re-evaluate different pieces of clinical information	Deliberately consider from another angle: "Let's play devil's advocate…" or "Let's re-review elements of the history…"	Cartmill, R.S.V. & Thornton, J.G; *Lancet*, 1992 McNeil et al; *NEJM*, 1982
Anchoring Heuristic:	Relying on initial impressions and not adjusting diagnostic probabilities properly with new data	Formally estimate probabilities in light of new data or second opinion; look up selected probability data on Pubmed; do this with *own* patient as you would when giving second opinion	"If the patient is not responding to treatment or is worsening, is one possibility that this is the wrong diagnosis? Have I properly weighed key clinical data in making a diagnosis?"	Tversky and Kahneman; *Science*, 1974
Availability Heuristic:	Judging by ease of recalling past cases based on recency or impact	Verify with legitimate statistics from the literature	"Am I unduly influenced by my experience with one memorable or recent case?"	Salem-Schatz et al; *JAMA*, 1990
Representative-ness Heuristic:	Ignoring prior probabilities and base rate frequencies of different diagnoses that seem to match the patient's pattern of presentation	Formally incorporate prior probability into considerations; look up literature on prevalence and occurrence of diseases	Pay attention to base rates: "If you hear hoof beats, think about horses not zebras."	Kahneman & Tversky; *Psychol Review*, 1973
Blind Obedience:	Showing undue deference to authority or technology	Look up diagnostic test performance characteristics in medical literature using Pubmed or other sources	"Does a negative value on a test definitively rule out a disease? How common are false positives?"	Woolf & Kamerow; *Arch Intern Med,* 1990

Adapted from Redelmeier, Ann Intern Med 2005

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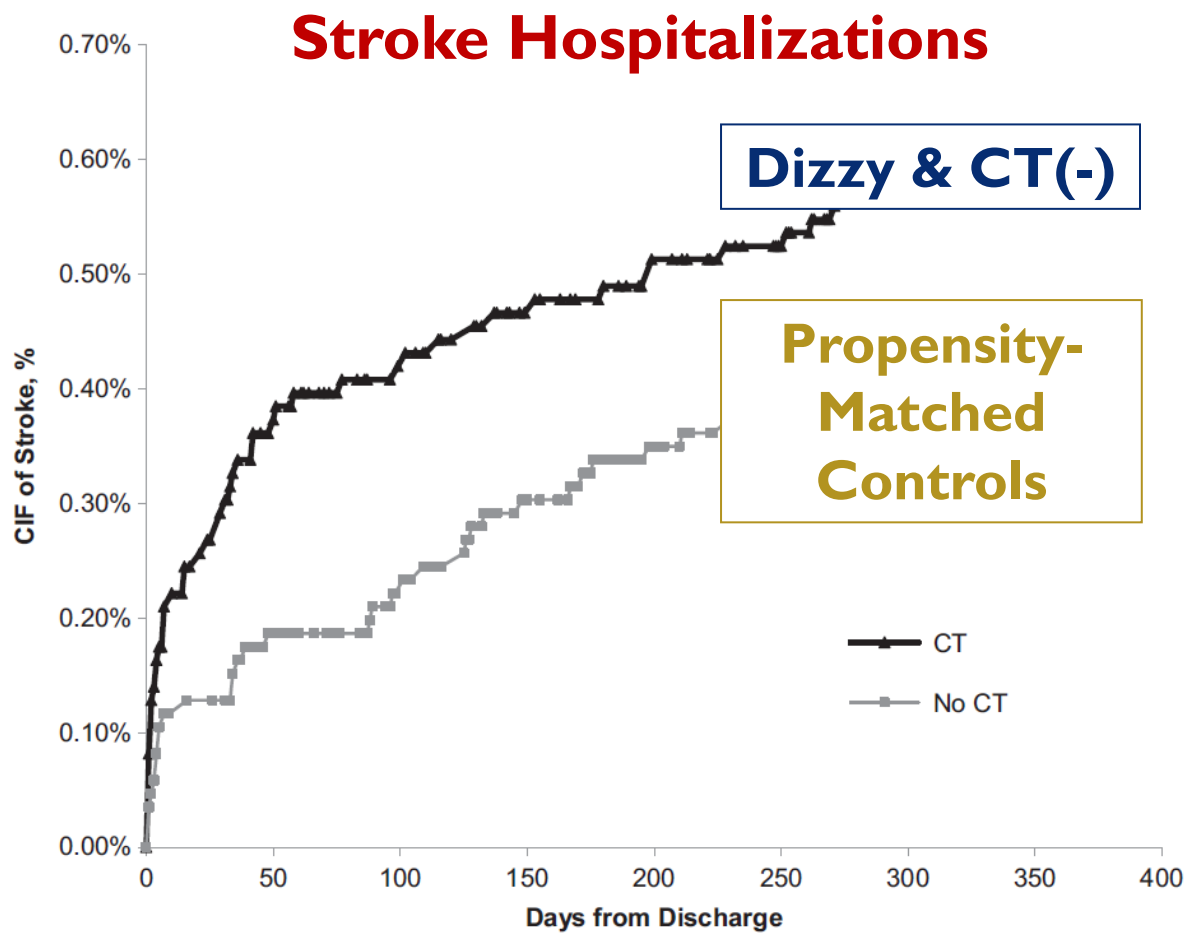
BASE CASE

Adapted from Redelmeier, Ann Intern Med 2005

False Reassurance from Negative CT Imaging

BASE CASE

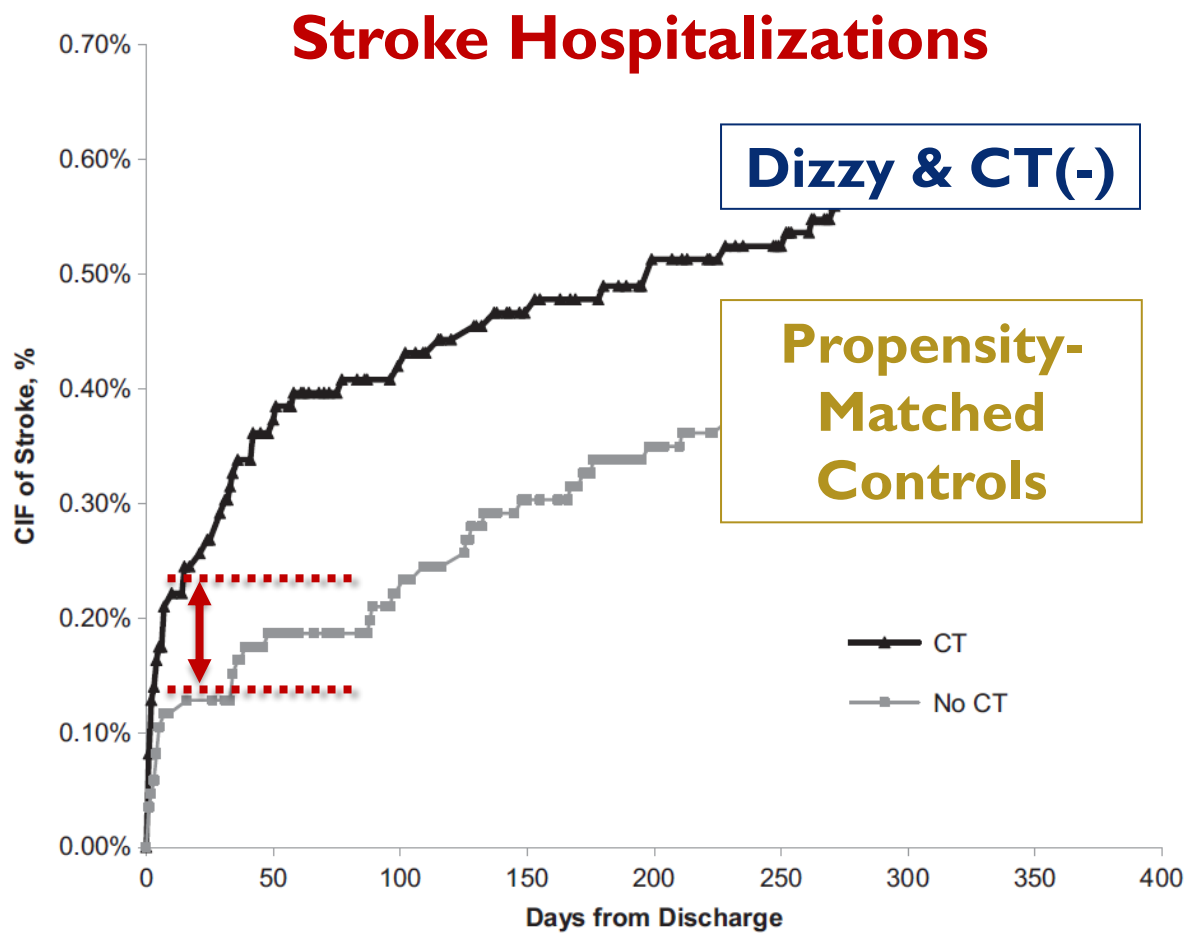


Imaging Misuse:
CT does not "rule out" stroke in dizziness… negative CT ***predicts*** future stroke (OR 2.3)

Grewal et al., Stroke 2015

False Reassurance from Negative CT Imaging

BASE CASE



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Grewal et al., Stroke 2015

Expertise Gaps

Diagnostic Errors – Diagnostic Expertise

1. **What it's Not: MYTHS**
   - Diagnostic expertise is based largely on innate gifts
   - Confidence accurately reflects competence
   - Diagnostic skills are universal

2. **What it Is: TRUTHS**
   - Diagnostic decisions vary in difficulty
   - Diagnostic decisions are context dependent
   - Great diagnosis is targeted and efficient

Experts are Made not Born

https://i.ytimg.com/vi/1-sjUoGO250/maxresdefault.jpg

Diagnostic Errors – Diagnostic Expertise

1. **Source**
   - Education (esp. "effortful study" – at your limits)
   - Experience (esp. with timely, guided feedback)
   - Reflection (esp. systematic practice improvement)

2. **Result**
   - Extensive domain knowledge (illness/symptom scripts)
   - Intuitive, accurate processing familiar diagnoses (Sys. 1)
   - Ability to solve new problems more accurately (Sys. 2)

Newman-Toker

Diagnostic Errors – Expertise vs. Specialization

Generalist* ≠ Lack of Expertise

Expert ≠ Specialist

Specialist ≠ Expert

Specialist = Easier to Gain Expertise

Newman-Toker

** Generalist assesses the full range of patient symptoms*

Diagnostic Errors – Why Diagnostic Expertise May be Lacking

1. Tough Task & Limitations of the Human Brain

- Generalists have a MUCH tougher task
- Cognitive and affective traps (biases)
- Overconfidence/miscalibration (lack of feedback)

2. Inadequate Education & Training

- Education does not focus on uncued diagnosis
- No one gets enough experience or training
- Time pressure limits practice improvement

Diagnostic Errors – Subtlety is a Huge Risk Factor

Obviousness predicts correct diagnosis

Subtlety predicts incorrect diagnosis

Points to Gaps in Expertise

a) low prevalence (pre-test probability / base rate)
b) degree of difficulty (atypical, non-specific, red herrings, "wrong" demographic group, bigger problems)
c) training background, knowledge/familiarity/expertise

Newman-Toker et al., AHRQ Report on Diagnostic Errors in the Emergency Department 2022

Diagnostic Errors – Two Dominant Theories re: Cognitive Causes

COGNITIVE BIAS

↓

Debiasing & Timeouts

EXPERTISE GAPS

↓

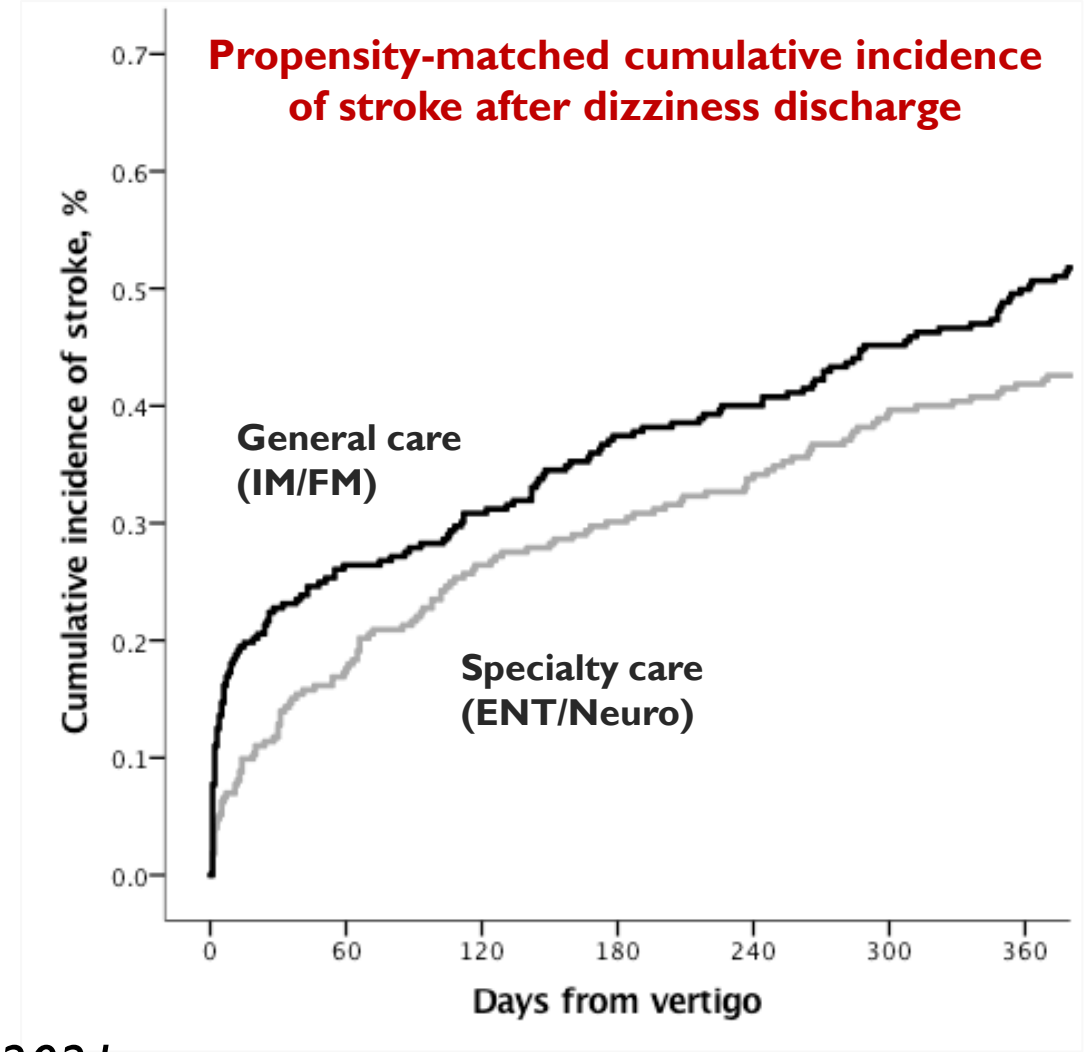
The Four T's

Team, Train, Tech, Tune

Newman-Toker

Expertise Helps in Diagnosing Dizziness

BASE CASE



Chang et al., Diagnosis (Berl.) 2021

Expertise Helps in Diagnosing Dizziness

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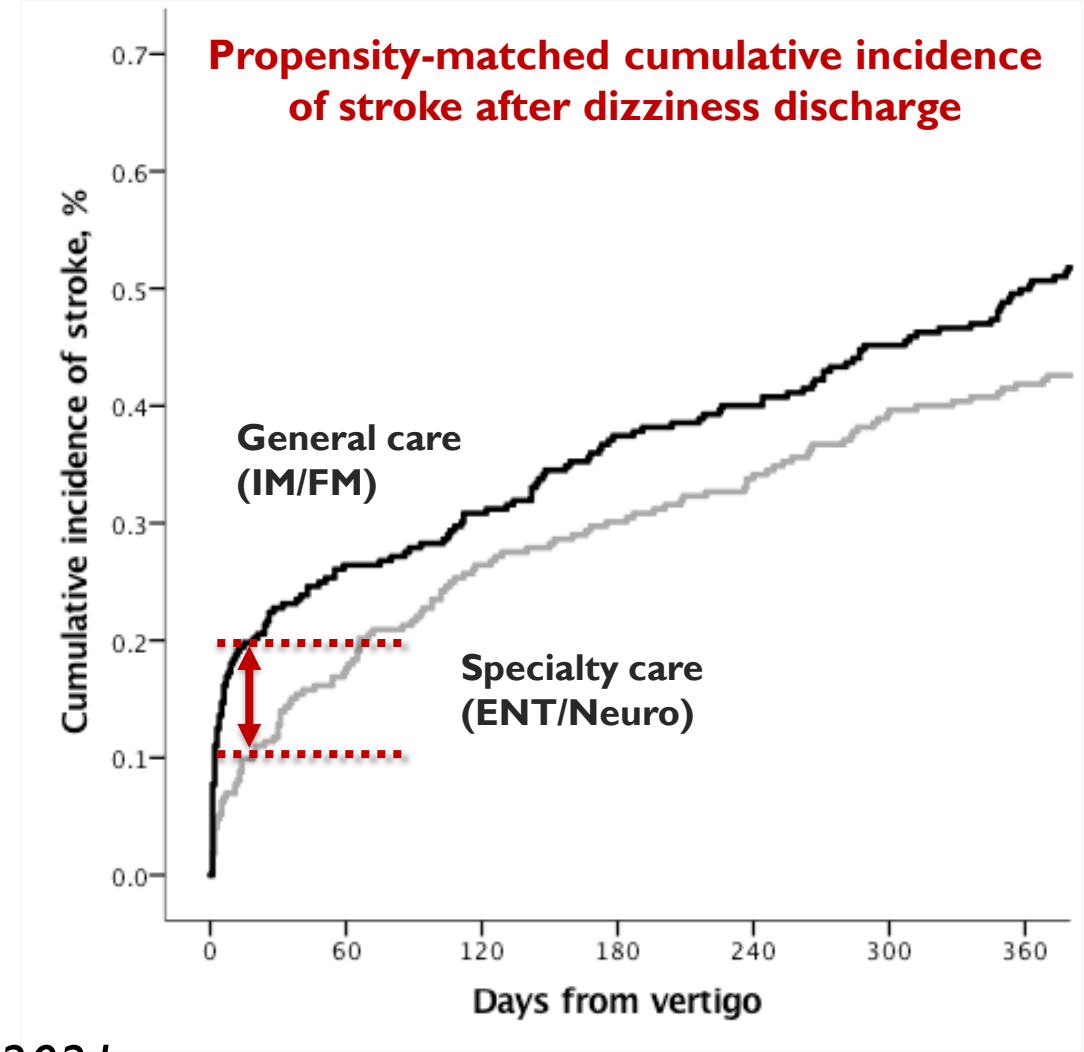
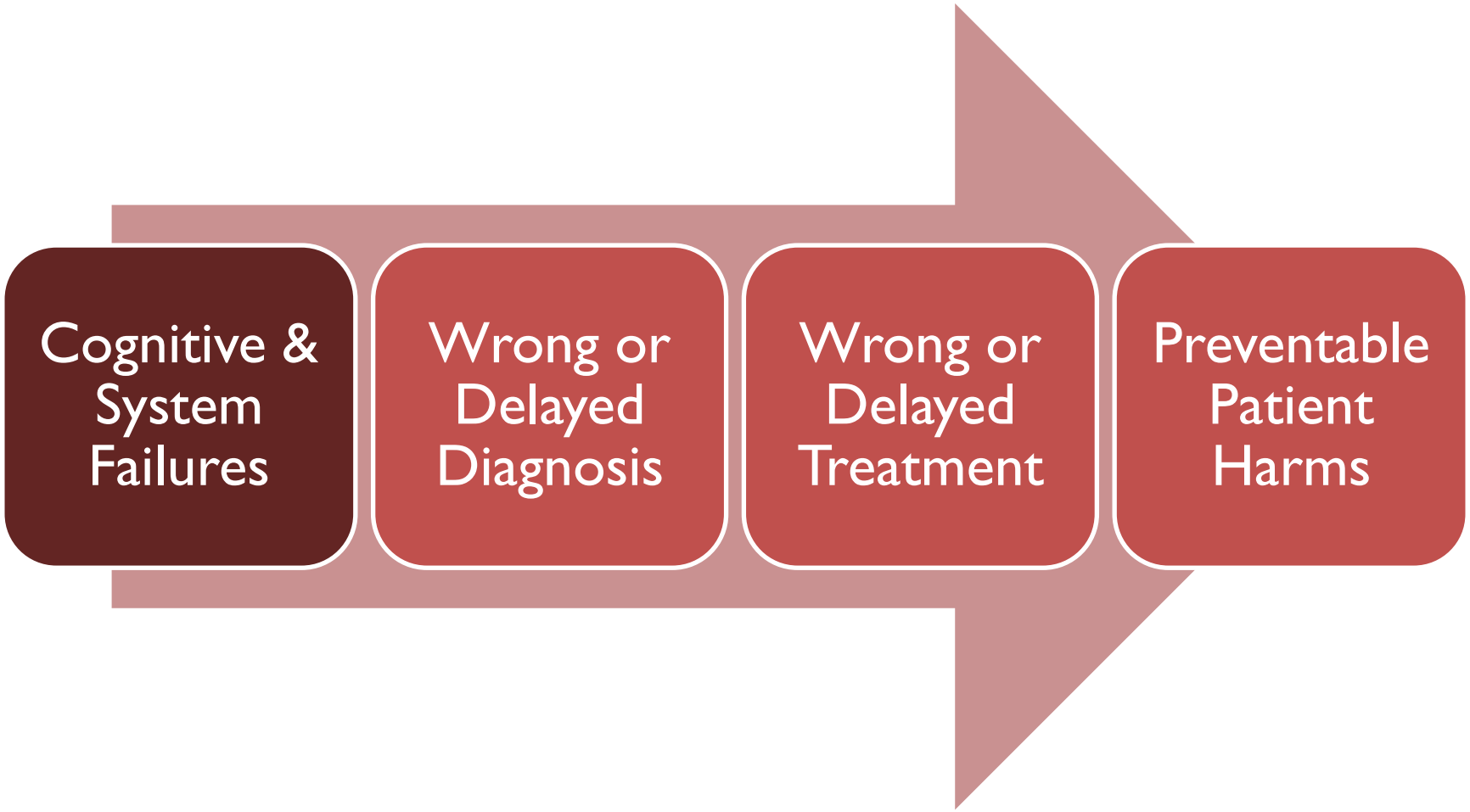


Chang et al., Diagnosis (Berl.) 2021

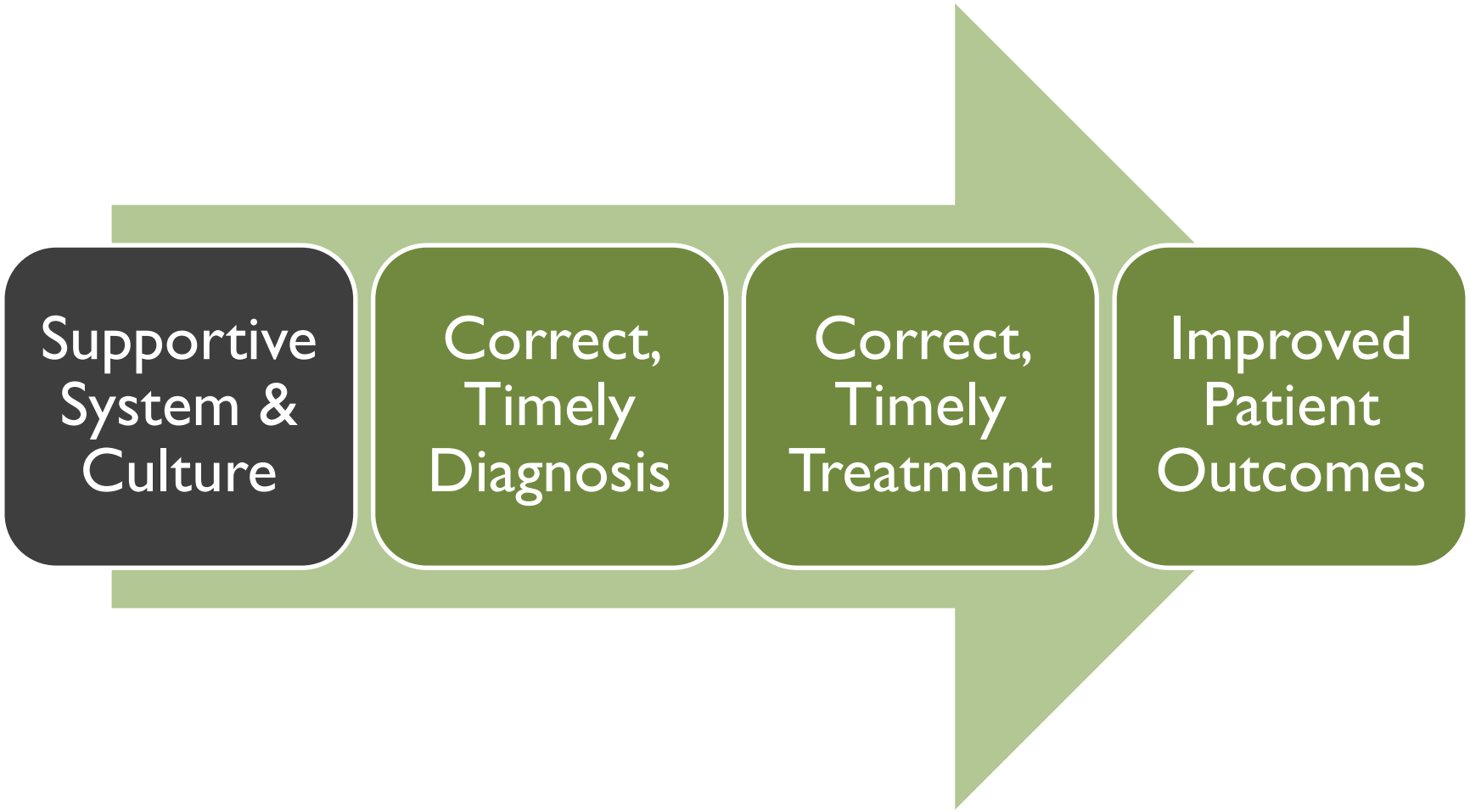
Work System

Diagnostic Errors – Failed Dx Processes & Outcomes



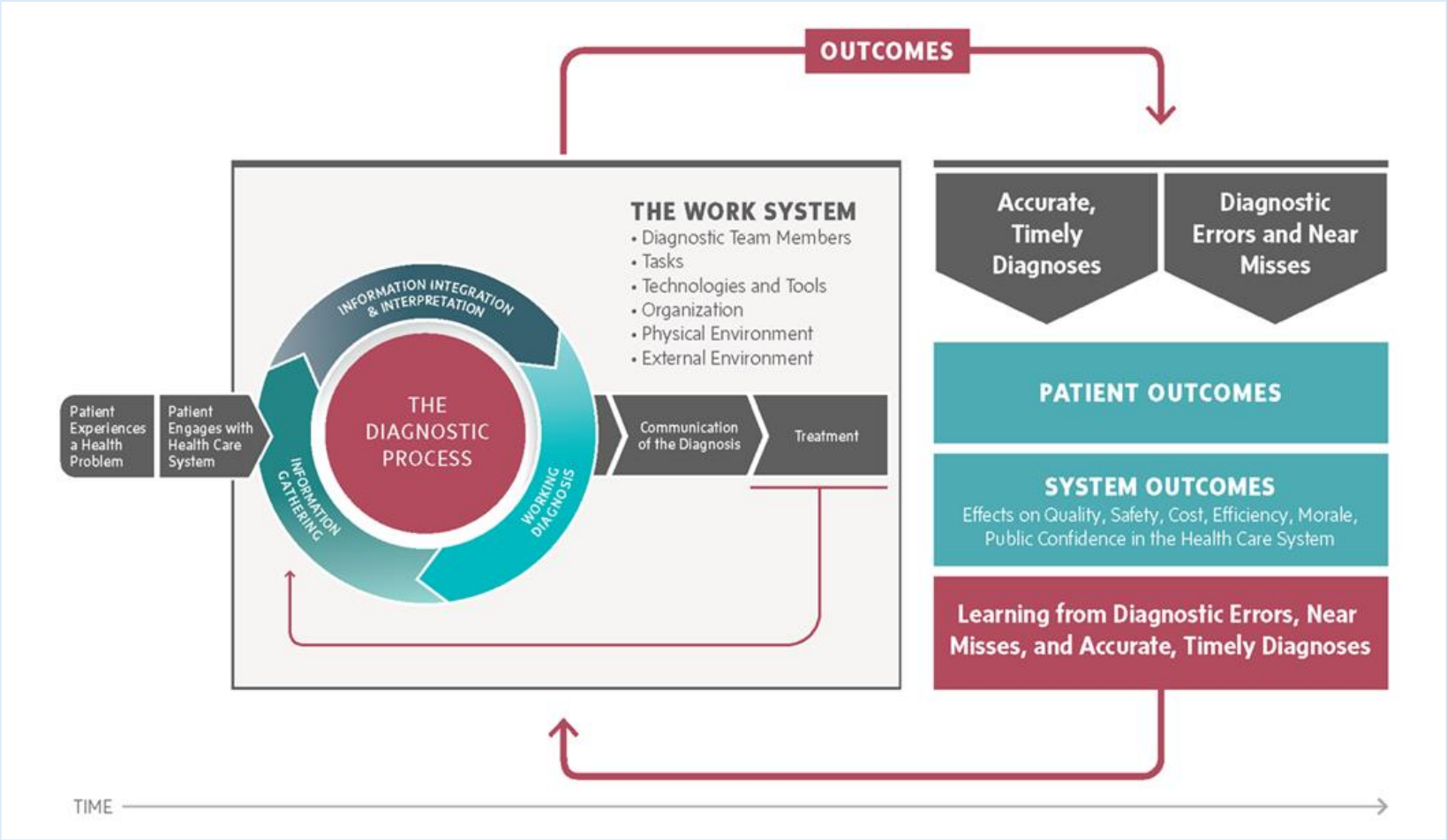
Newman-Toker

Diagnostic Excellence – Optimal Dx Processes & Outcomes



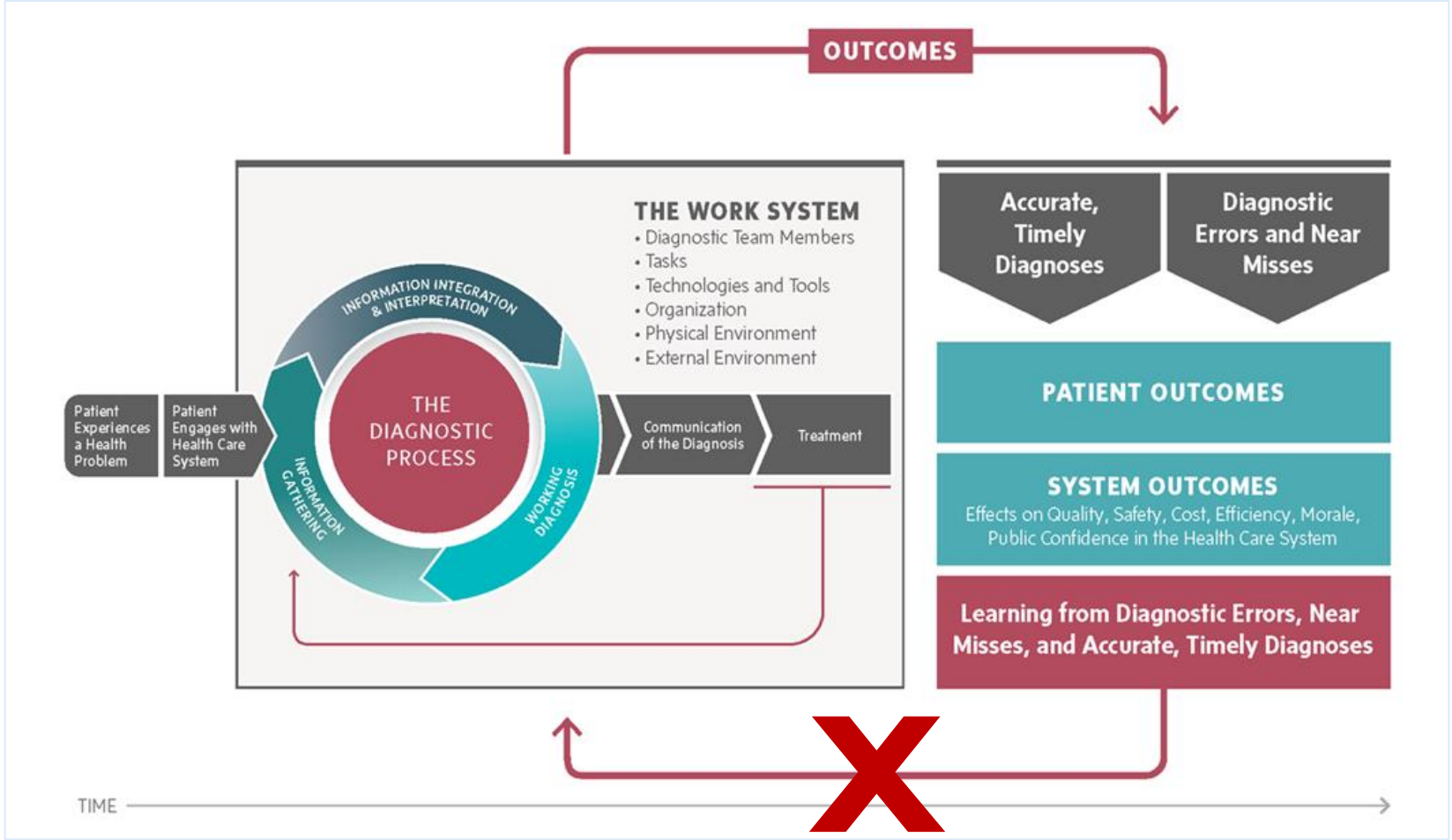
Newman-Toker

Diagnostic Excellence – Learning Health System Concept



National Academy of Medicine, Improving Diagnosis in Healthcare 2015

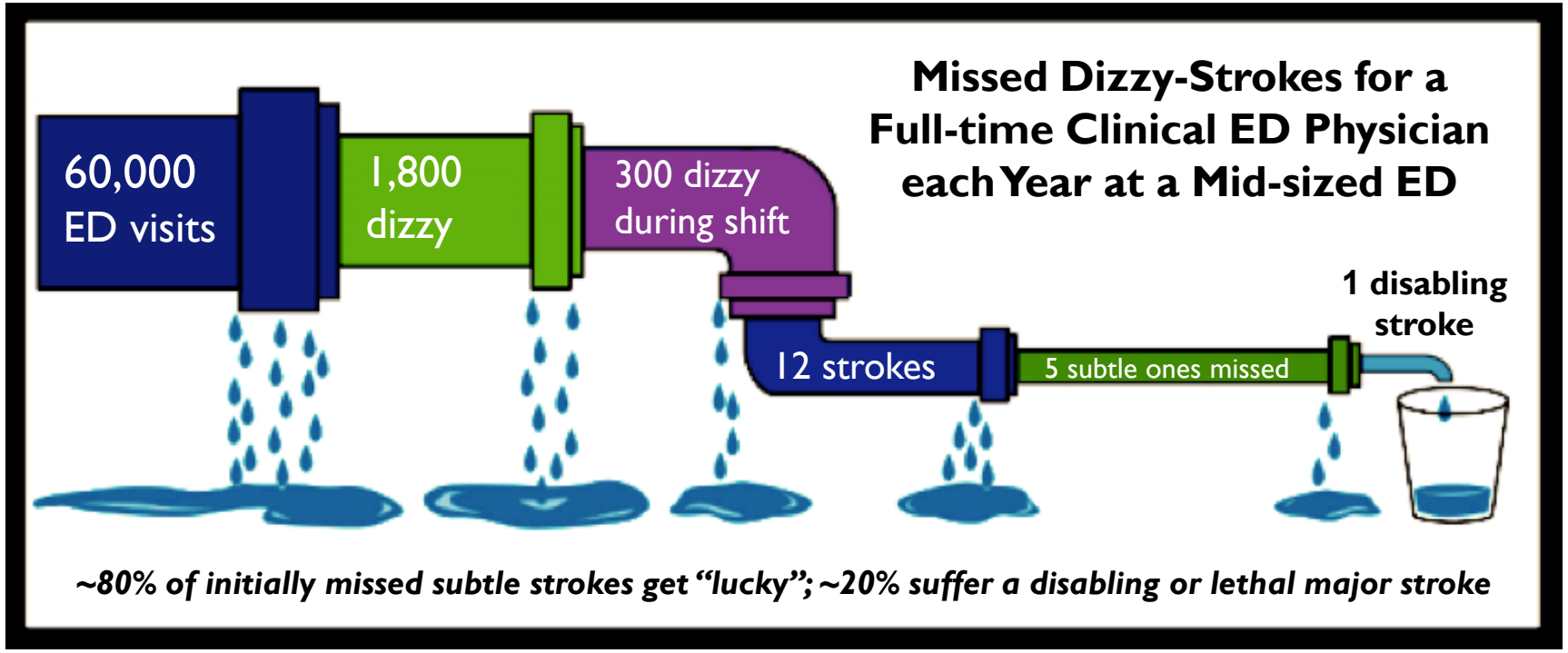
Diagnostic Excellence – Learning Health System Concept



National Academy of Medicine, Improving Diagnosis in Healthcare 2015

Diagnostic "Calibration Gap" Makes it Tough to Learn

BASE CASE



Omron et al., Academic Emergency Medicine Education 2018

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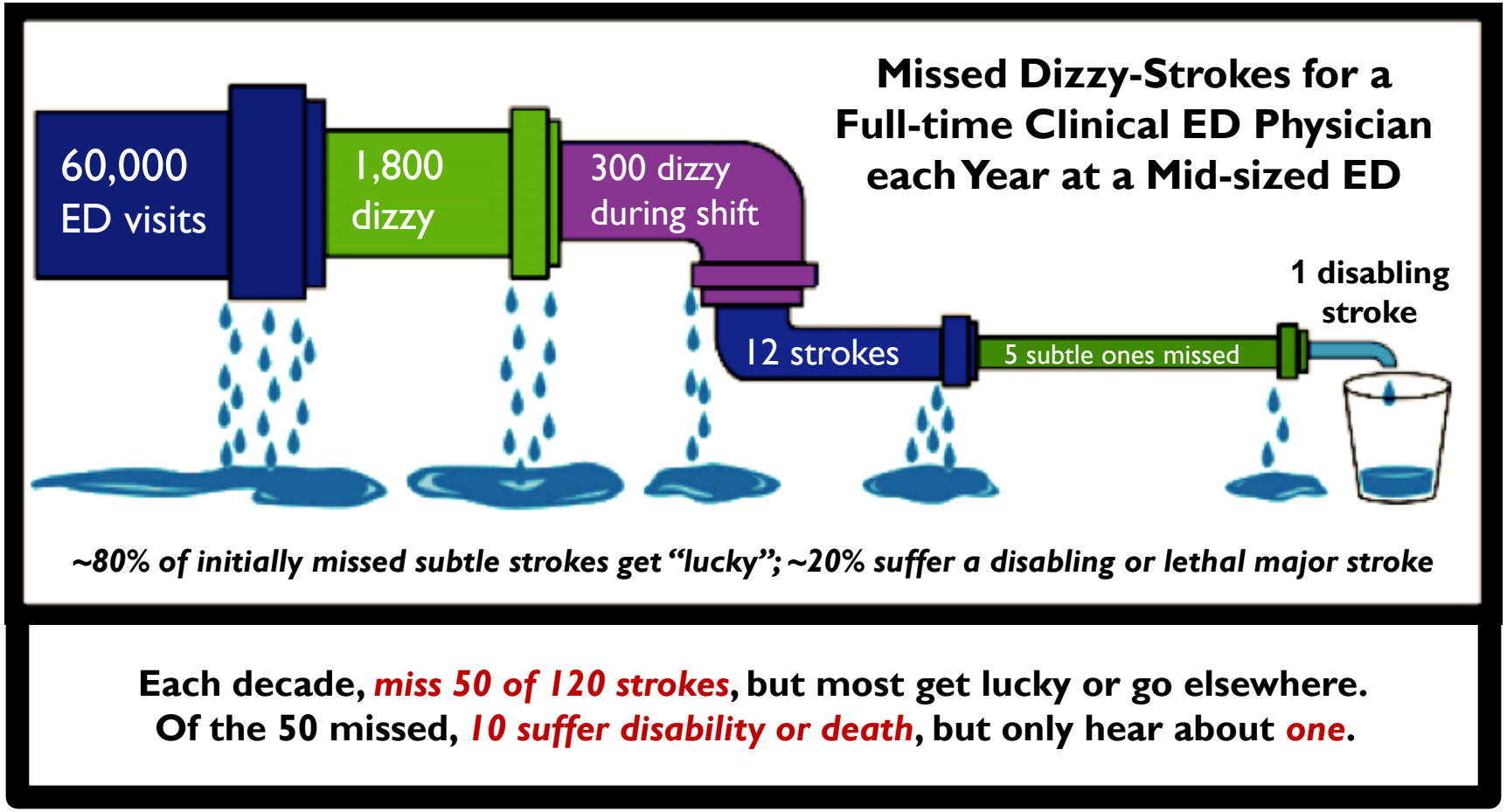


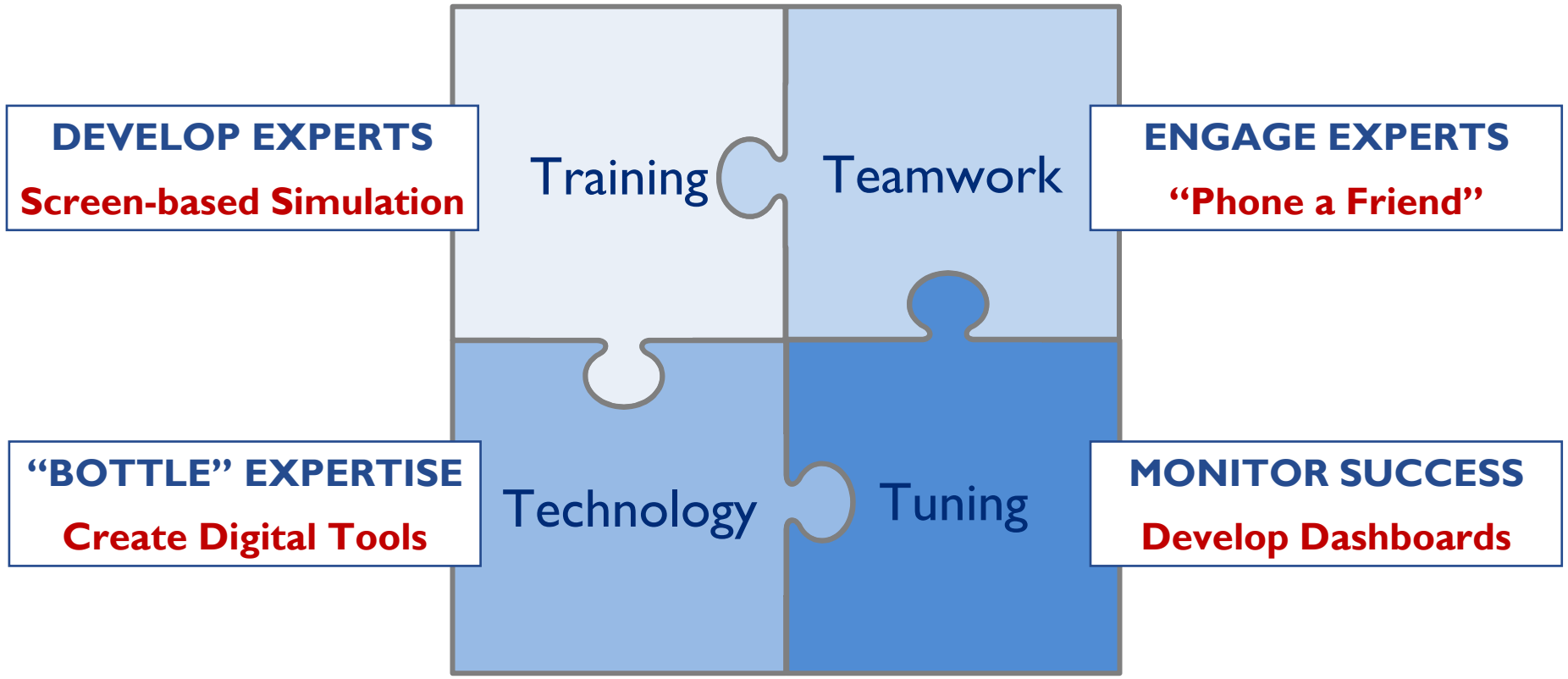
Perceived Dx Accuracy = ~99%

Actual Dx Accuracy = ~60%

Omron et al., Academic Emergency Medicine Education 2018

Systems Solutions

Diagnostic Excellence – Four Ts to Transform Diagnosis

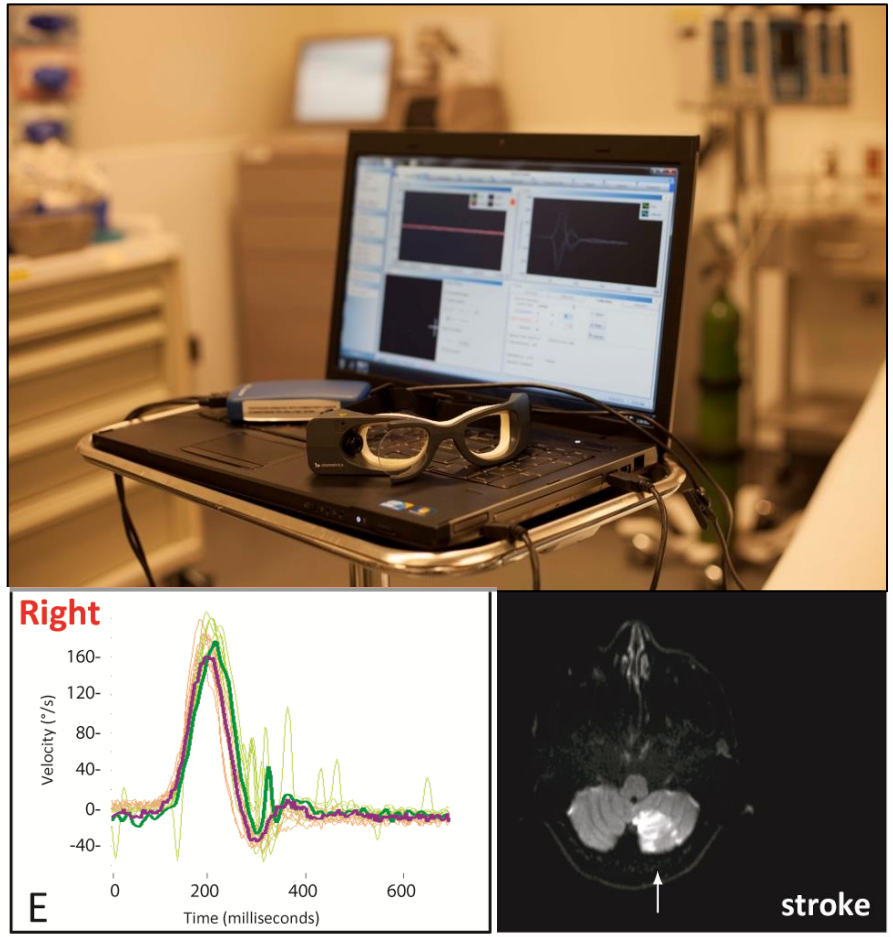


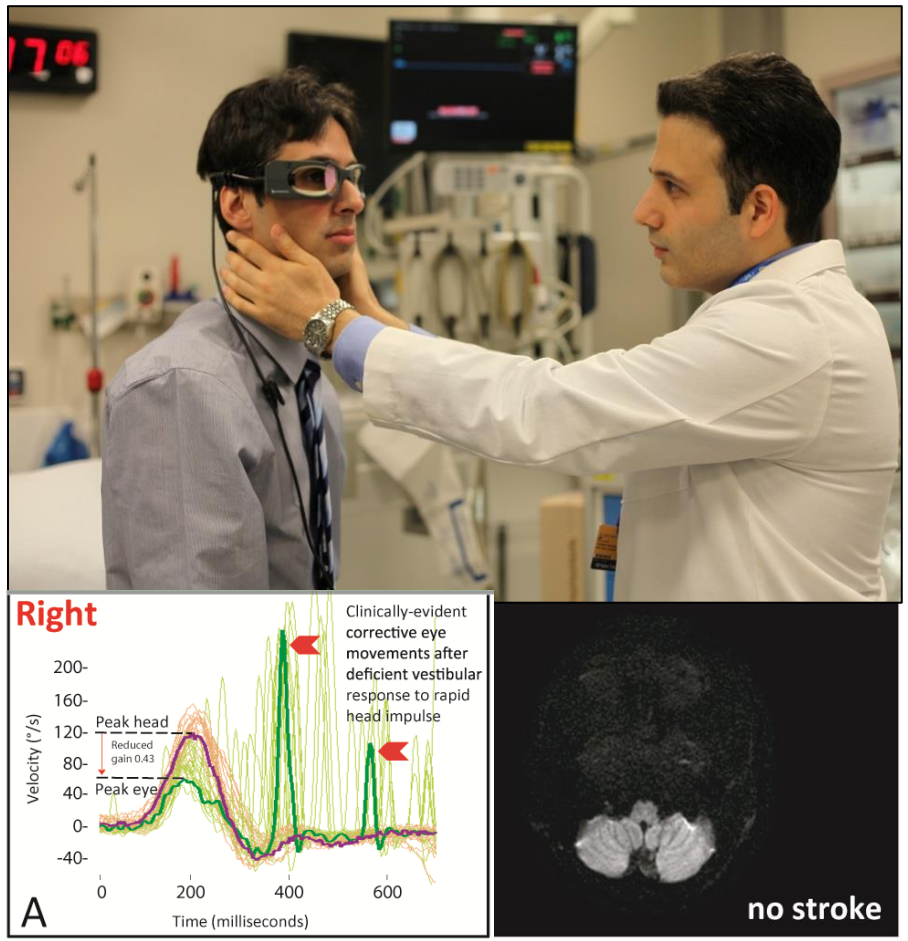
Newman-Toker

Four Ts – #1 Teamwork

Portable Video-Oculography – The "Eye ECG"

BASE CASE





Newman-Toker et al., Stroke 2013

Tele-Dizzy Subspecialty Consultation Service Process

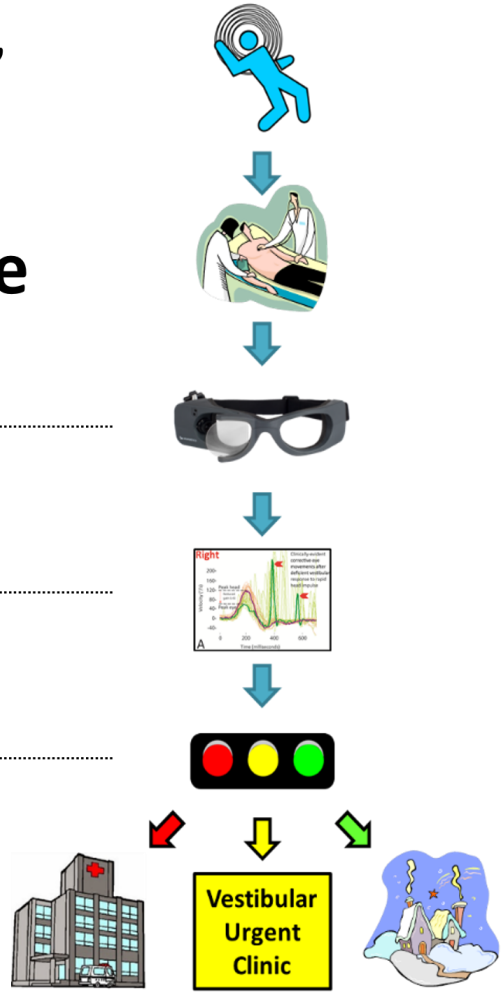
BASE CASE

VOG Rapid Triage – "Eye ECG"
via
Tele-Dizzy Consultation Service

Local Personnel
Perform VOG Tests

Remote Experts
Interpret VOG Results

Disposition Recommendation
Within 1 Hour of Testing



Newman-Toker

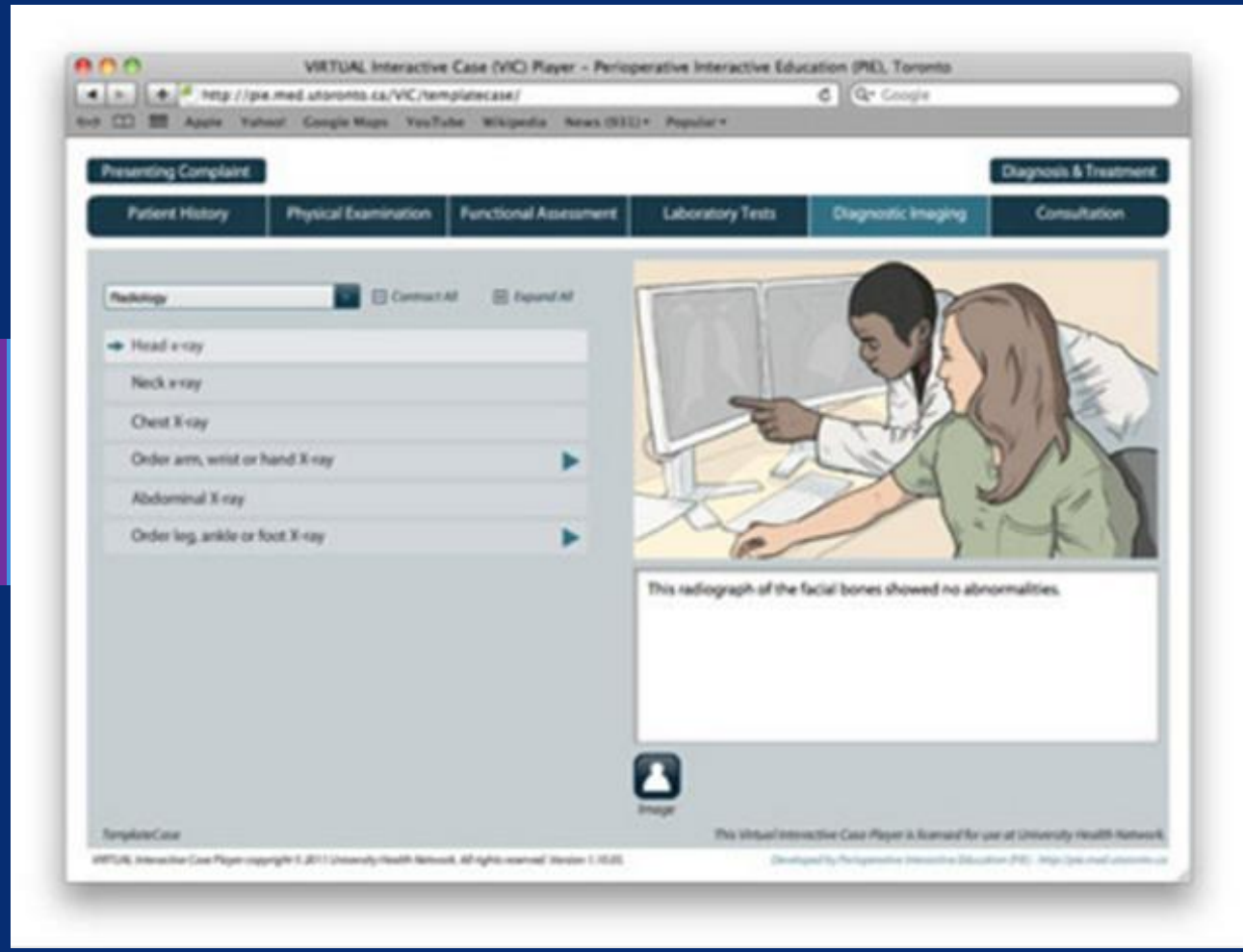
VOG-Based Tele-Dizzy Consultation Service Successes

BASE CASE

p<0.0001 for each comparison except MRI utilization (p=0.95)

Gold, Bárány Society Meeting 2022

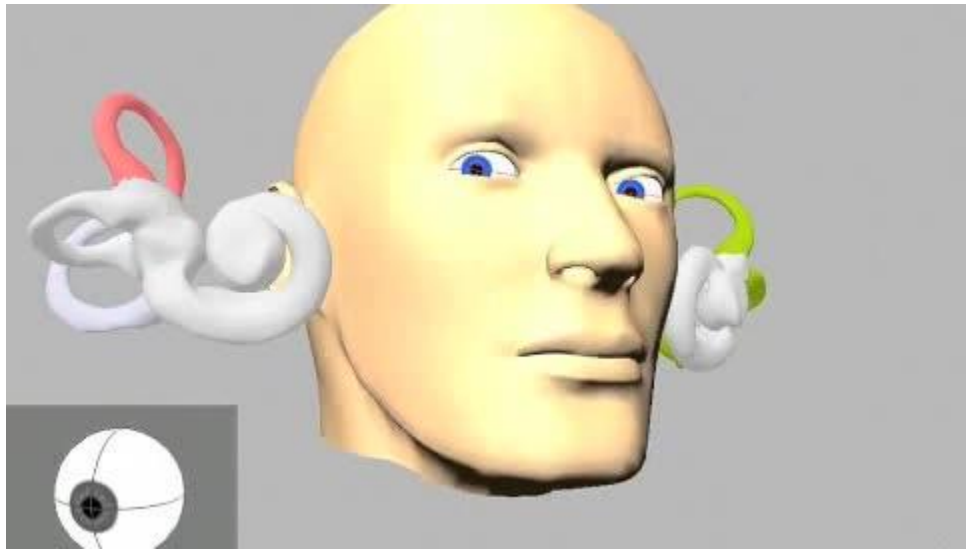
Four Ts – #2 Training



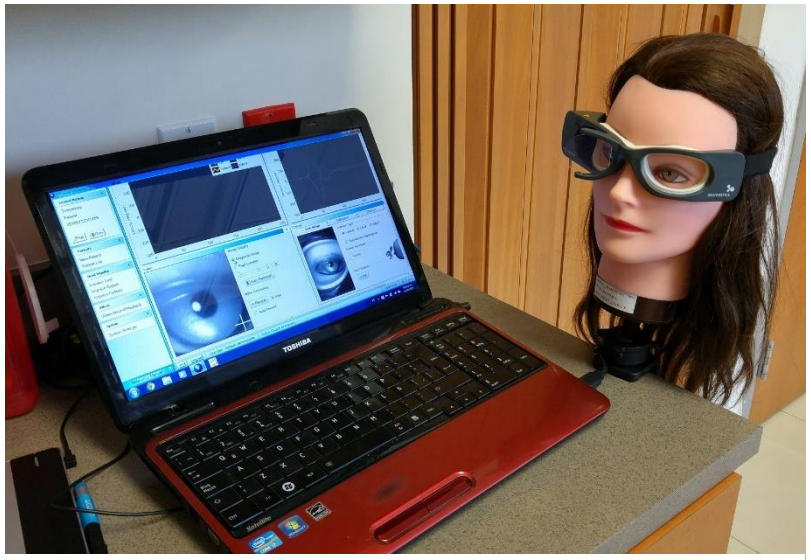
Virtual Interactive Case (VIC) Player (*Gord Tait, University of Toronto*)

Gamification of Training Using Simulation

BASE CASE



aVOR 'app' (MacDougall)



'Rosita' (Ceballos)

Building a simulation training library of real-world cases

Cognitive (history-taking) + psychomotor (exam) skills

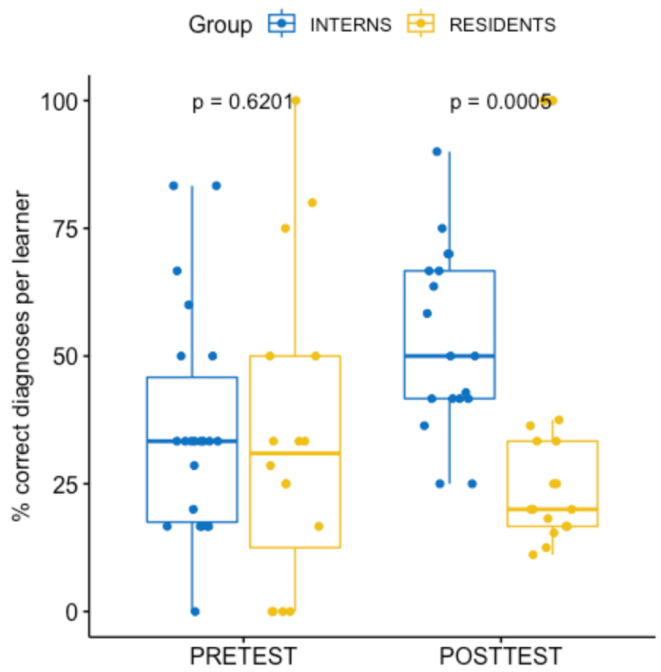
= **SCALABLE DIAGNOSTIC EXPERTISE**

Kotwal et al., Diagnosis (Berl.) 2021

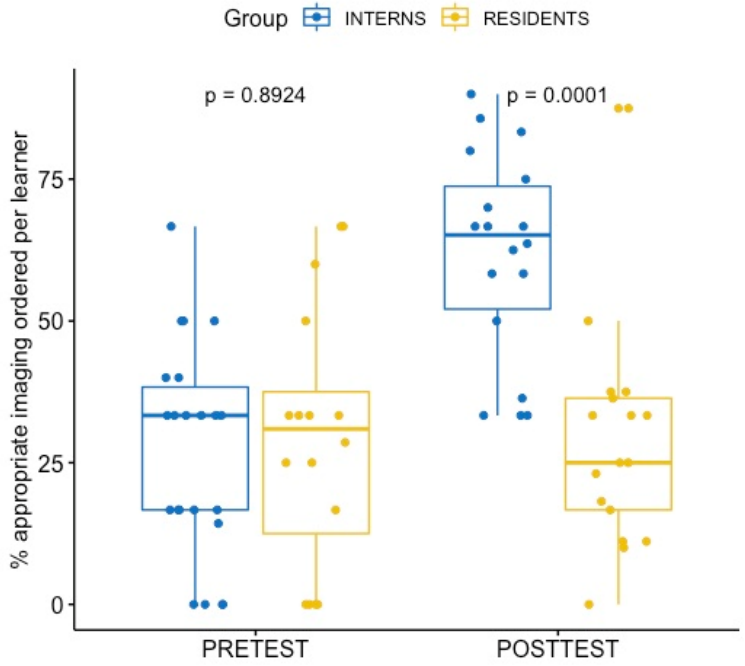
Virtual Patient Training Outperforms Residency

BASE CASE

Diagnostic Accuracy



Appropriate Imaging

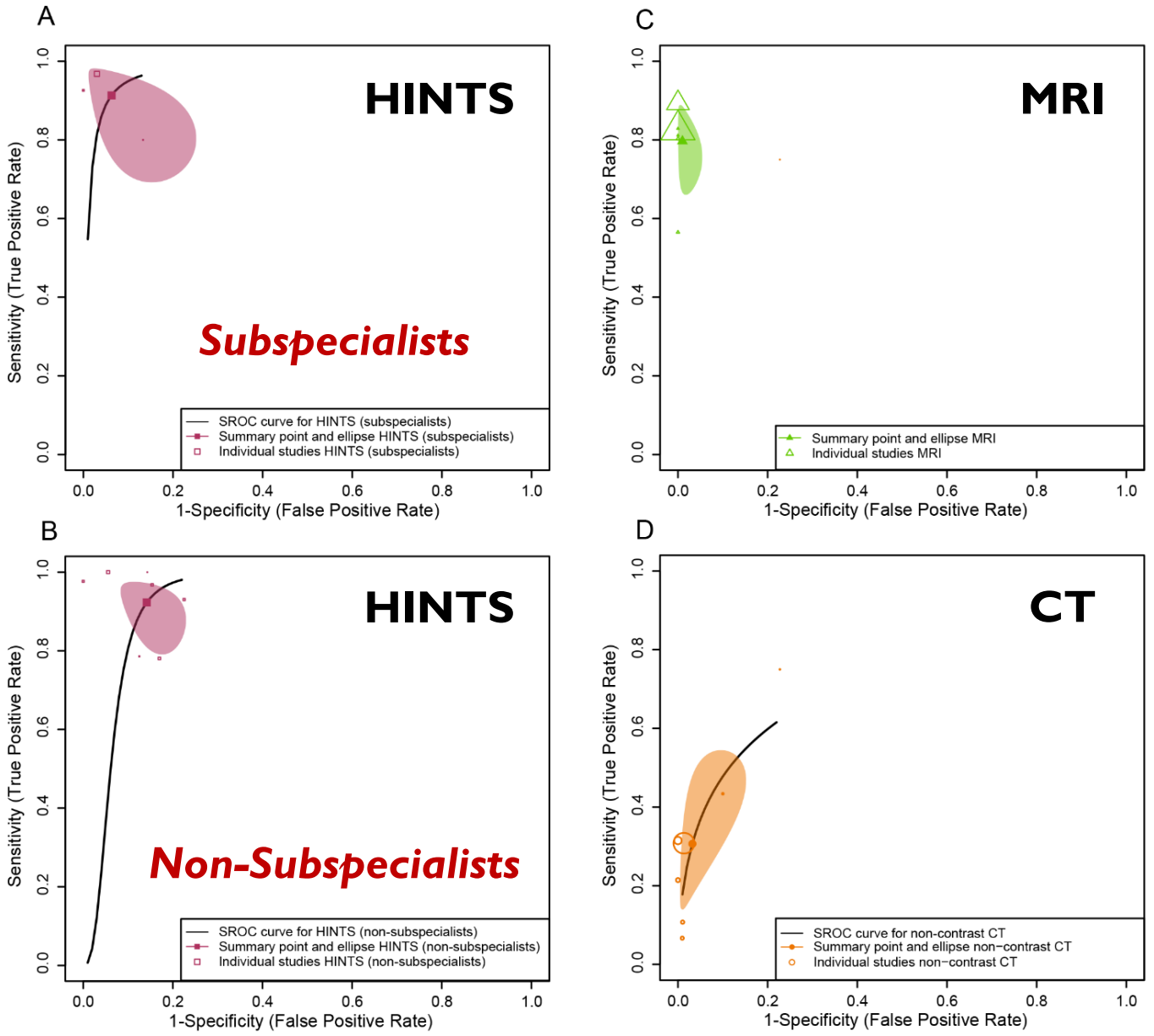


9 Hours of Sim Training Better than 2 Years of Medicine Residency

Kotwal et al., Diagnosis (Berl.) 2021

ED Clinicians Can Be Trained to Use HINTS at Expert Level

BASE CASE

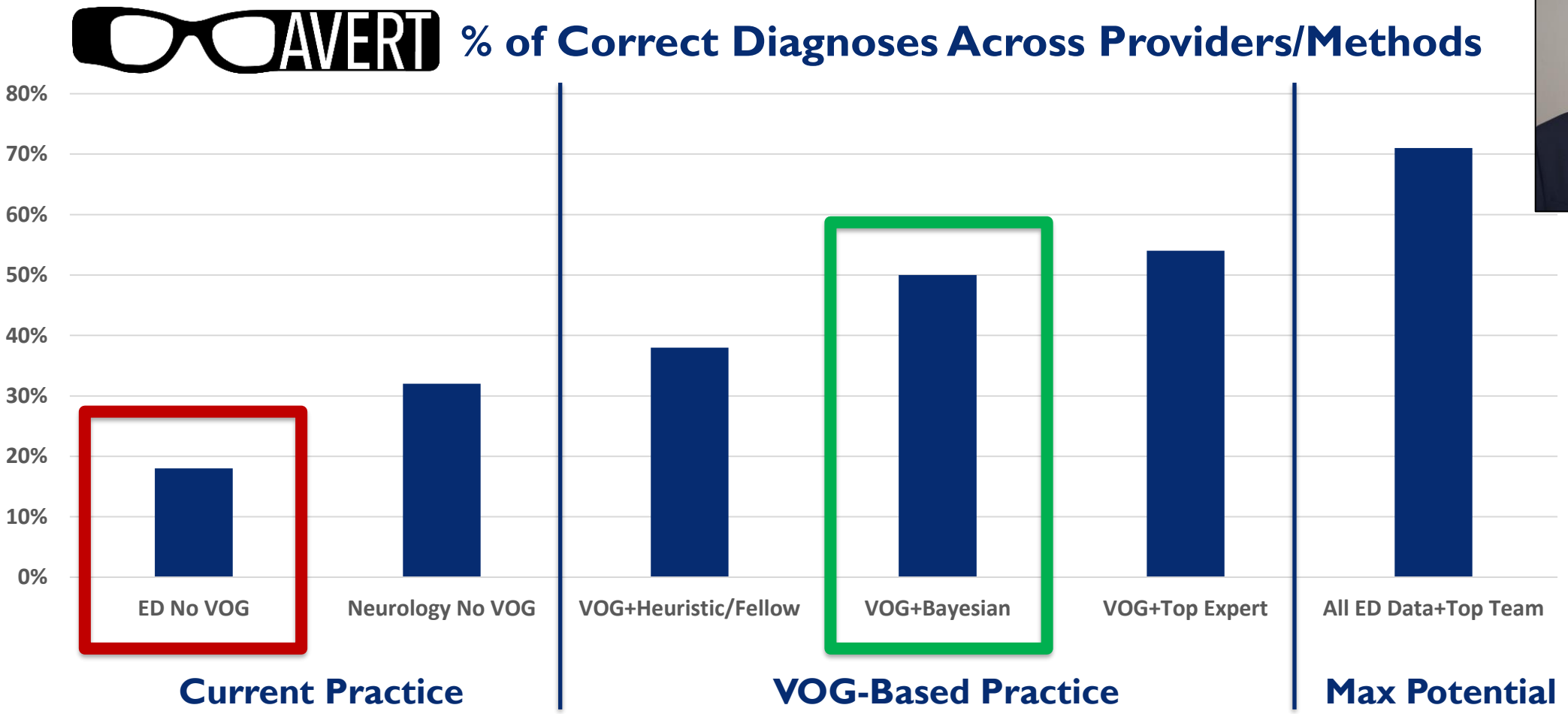


Tarnutzer et al., Annals of Neurology 2023

Four Ts – #3 Technology

Algorithms Already Outperform Current Practice

BASE CASE



Newman-Toker, Bárány Society Meeting 2024

“eyePhone” Mobile App

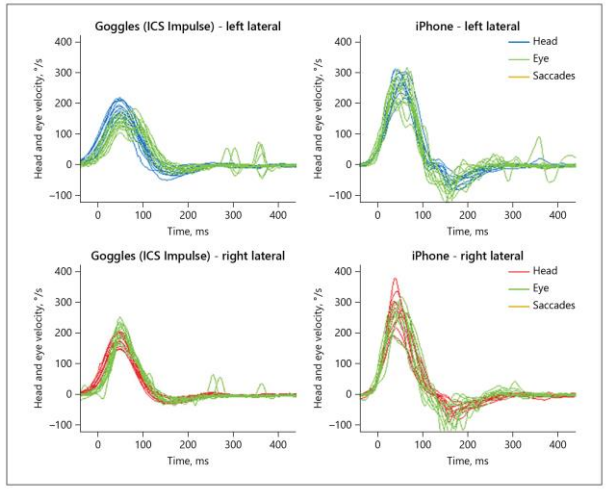
BASE CASE

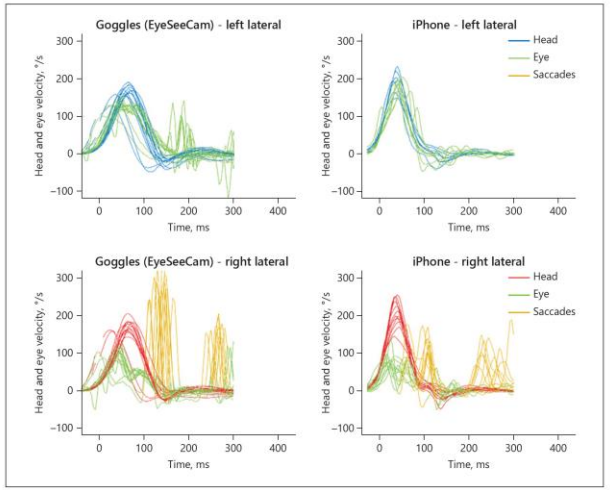
US Provisional Patent No. 62/883,373

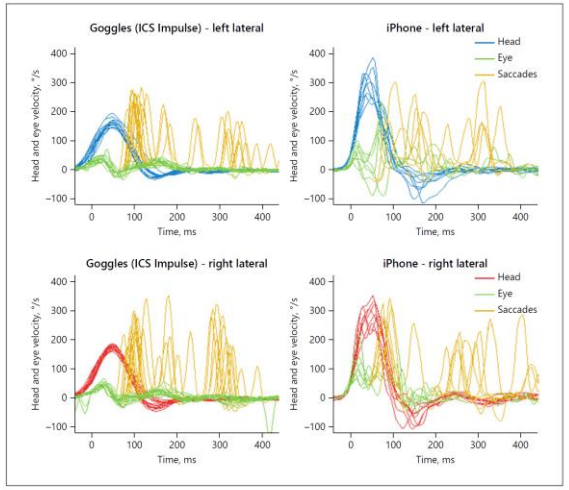
Parker et al., Digit Biomarkers 2021
Parker et al., Digit Biomarkers 2022

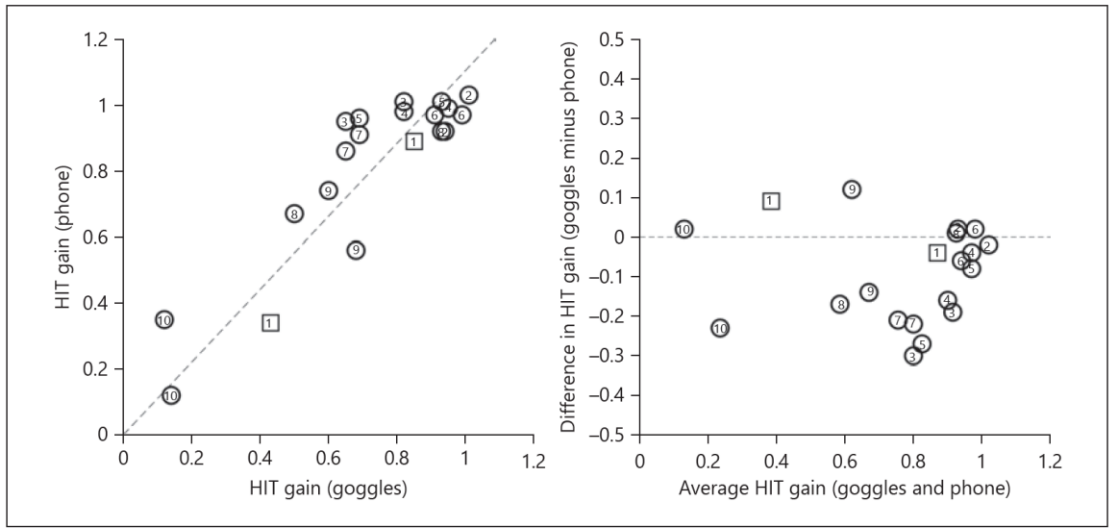
“eyePhone” Measurement Comparable to VOG

BASE CASE



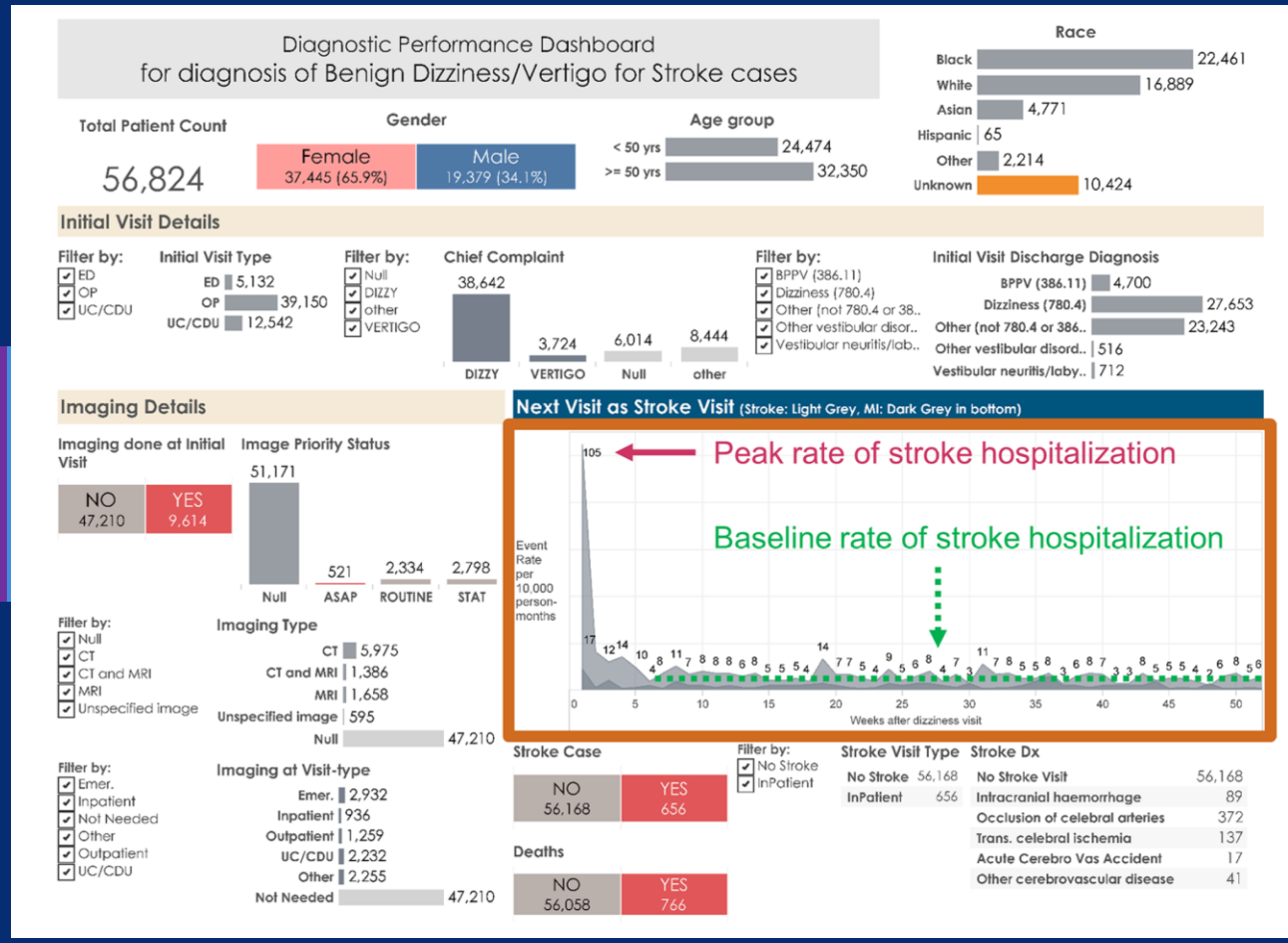






Parker, Digit Biomarkers 2021

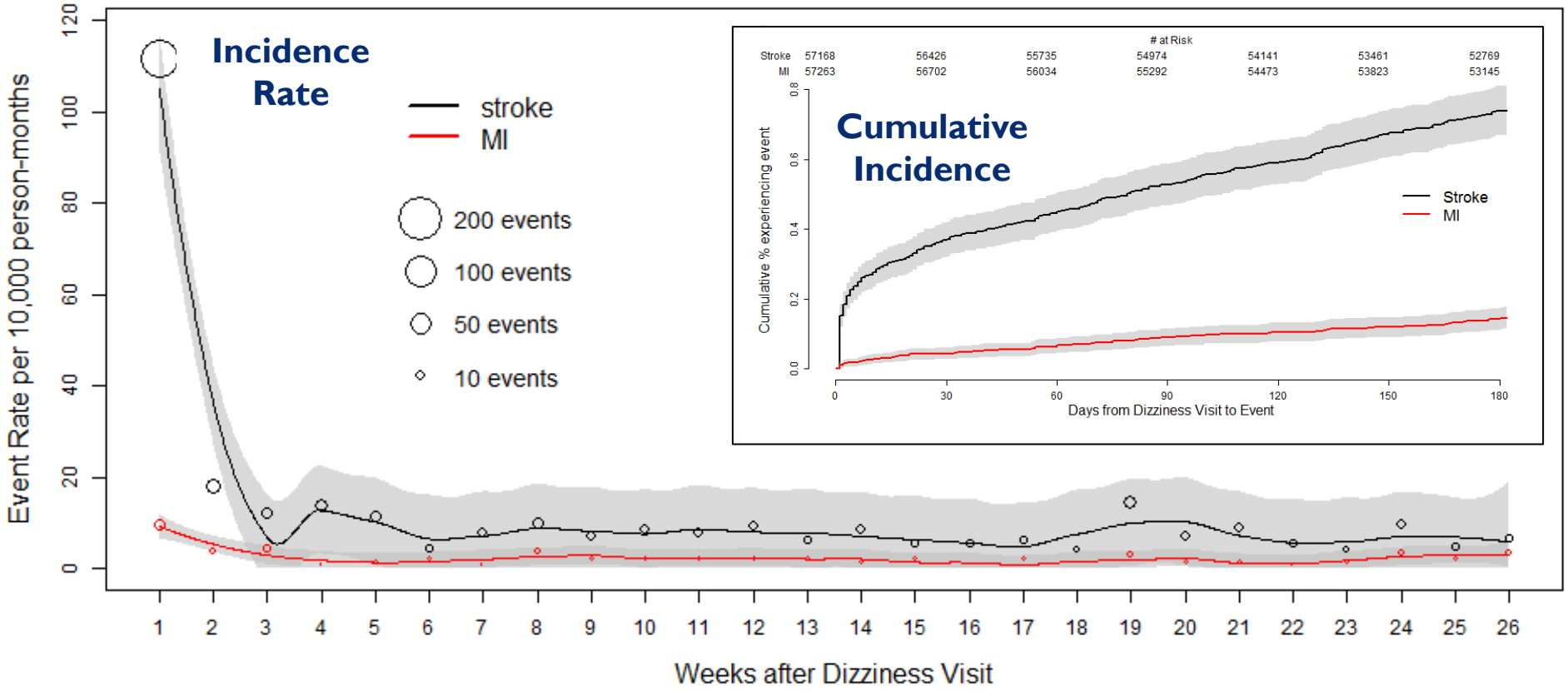
Four Ts – #4 Tuning



Mane et al., BMJ Quality & Safety, 2018

Creating "Needles" that We Can "Move" Toward Excellence

Weekly Incidence of Stroke & Heart Attack after a "Benign" ED Dizziness Discharge



Nassery et al. (using KP – JHM Collaborative Grant, 2016; MAPRI Co-I Ketan Mane)

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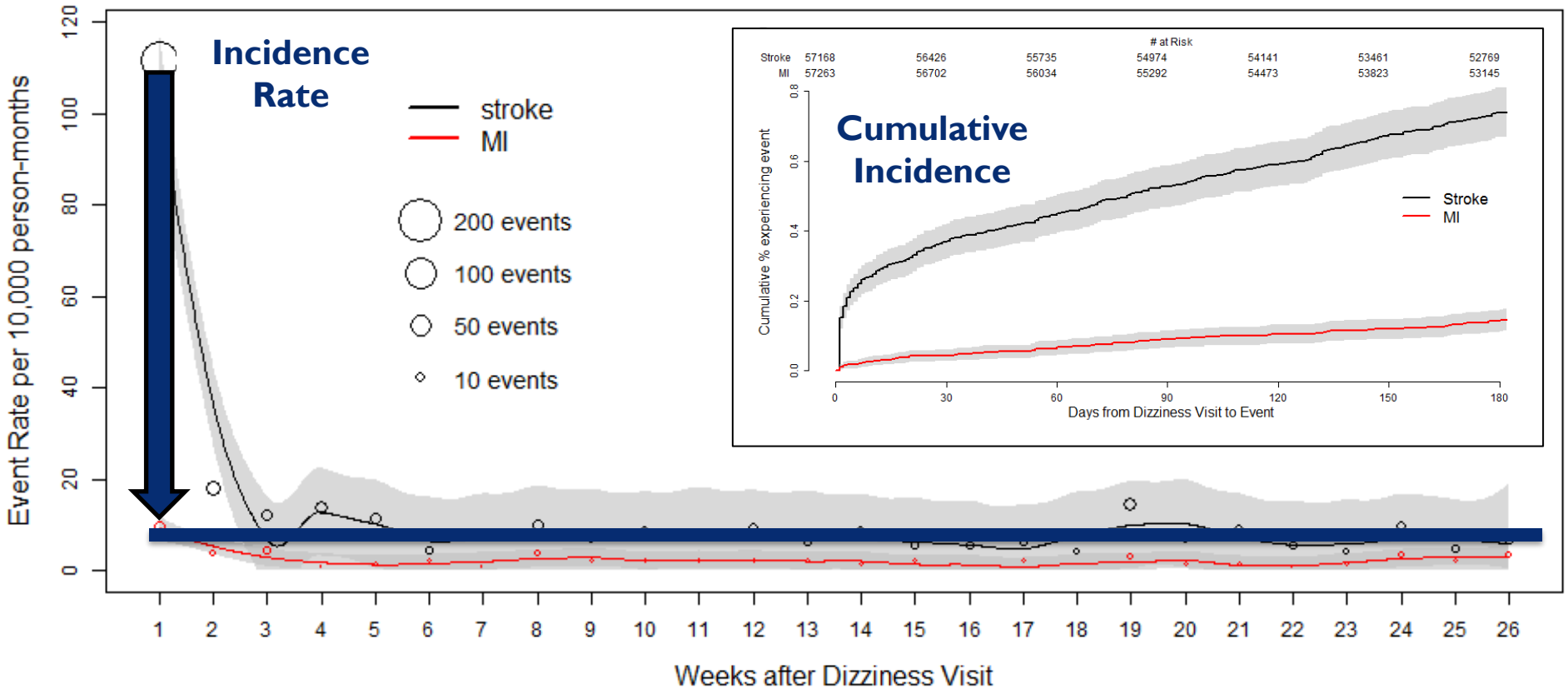


Nassery et al. (using KP – JHM Collaborative Grant, 2016; MAPRI Co-I Ketan Mane)

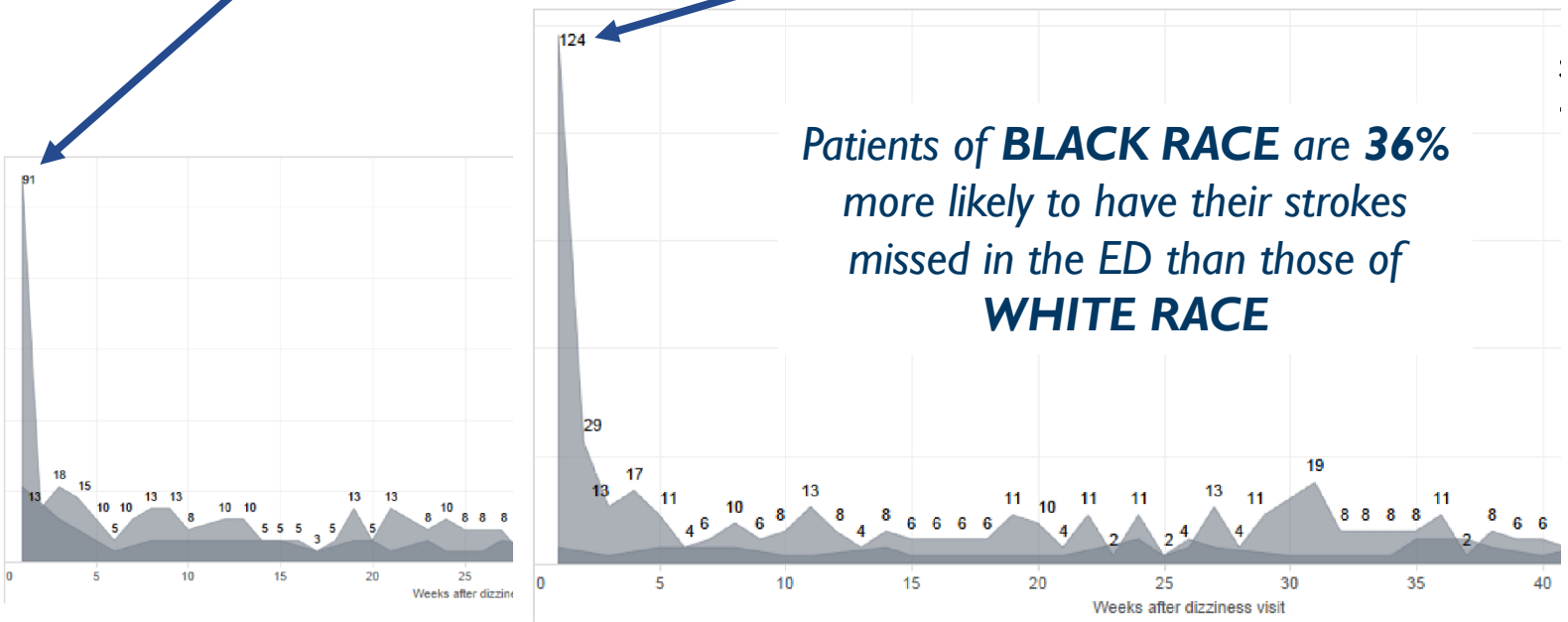
Monitoring Progress towards Eliminating Disparities

BASE CASE

Peak rate of stroke hospitalization for patients of **WHITE** vs. **BLACK RACE**

WHITE RACE = **91** per 10,000 person months with peak to baseline rate ratio = **12.7**

BLACK RACE = **124** per 10,000 person months with peak to baseline rate ratio = **16.9**



*Patients of **BLACK RACE** are **36%** more likely to have their strokes missed in the ED than those of **WHITE RACE***

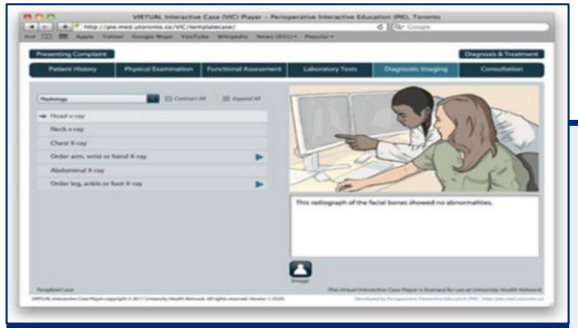
Mane et al., BMJ Quality & Safety 2018

Epilogue: The Base Case

John Michael Night

D.X. – Four Ts to Deliver Expertise at Scale

BASE CASE

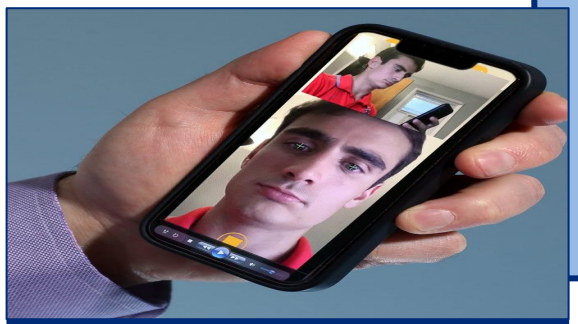


Build Expertise:
Screen-Based Simulation

Training

Teamwork

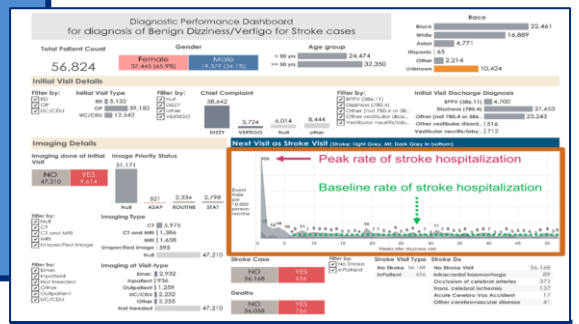
Engage Experts:
Tele-Dizzy



Bottle Expertise:
"eyePhone" mobile app

Technology

Tuning



Monitor Success:
SPADE Dashboards

Newman-Toker

Care Transformation: CPG, Quality Metric, & Payment

BASE CASE

Practice Guideline

First Ever Clinical Practice Guideline for Emergency Medicine

GRACE CLINICAL PRACTICE GUIDELINE

CME

Guidelines for reasonable and appropriate care in the emergency department 3 (GRACE-3): Acute dizziness and vertigo in the emergency department

Edlow et al., Acad EM 2023

Performance Measure

First US Nationally Endorsed "Avoid H.A.R.M." Quality Metric

Partnership for Quality Measurement

About · E&M · CQMC · PRMR · MSR · Measures · Public Comments · Get Involved · Contact

Avoid Hospitalization After Release with a Misdiagnosis—ED Stroke/Dizziness (Avoid H.A.R.M.—ED Stroke/Dizziness)

Austin & Newman-Toker, 2023

Payment Policy

HSCRC – Advancing Innovation in Maryland Program

health services cost review commission

Advancing Innovation in Maryland

HSCRC Website

Key Takeaways

Key Takeaways – CCC, Big Three, 4Ts

- An estimated 900,000 Americans suffer death or permanent disability each year from diagnostic errors at a societal cost of >$200 billion.
- The Big Three (vascular events, infections, and cancers) account for 75% of the serious harms from diagnostic error. Vascular events are #1 in the ED. Missed stroke causes the most harm. Atypical, non-specific, or otherwise atypical presentations represent the biggest risk factor.
- Strategies to achieve diagnostic excellence and minimize misdiagnosis-related harms are Teamwork, Training, Technology, and Tuning. The 4Ts should be applied as wraparound solutions for each symptom-disease pair, emphasizing converting "off pathway" patients to "on pathway."