DIAGNOSTIC REASONING AND DIAGNOSTIC ERROR IN MEDICINE

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Content

- The burden of diagnostic errors
- Complexity of the diagnostic process
- Dual process theory
  - The use of heuristics in the diagnostic process
  - Risk of cognitive bias
  - The role of content specific knowledge
- Ways to improve diagnostic safety
- Safety-II

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The burden of diagnostic errors

- 10-15% of the diagnoses are not entirely correct [1]
- Most people will experience a diagnostic error in their lifetime [2]
- Highly preventable and high mortality rates[3,4]
- Prevalent in malpractice claims [4]

1. Berner & Graber, Am J Med, 2008
2. National Academies of Medicine, 2015
3. Zwaan et al. Arch Intern Med, 2010
4. Bishop et al. JAMA, 2011

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Patient Safety Priority

National Academy of Medicine Report

Diagnostic Errors on WHO high priority list

ECRI: Diagnostic Errors Tops List of Patient Safety Concerns

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Complexity of the diagnostic process

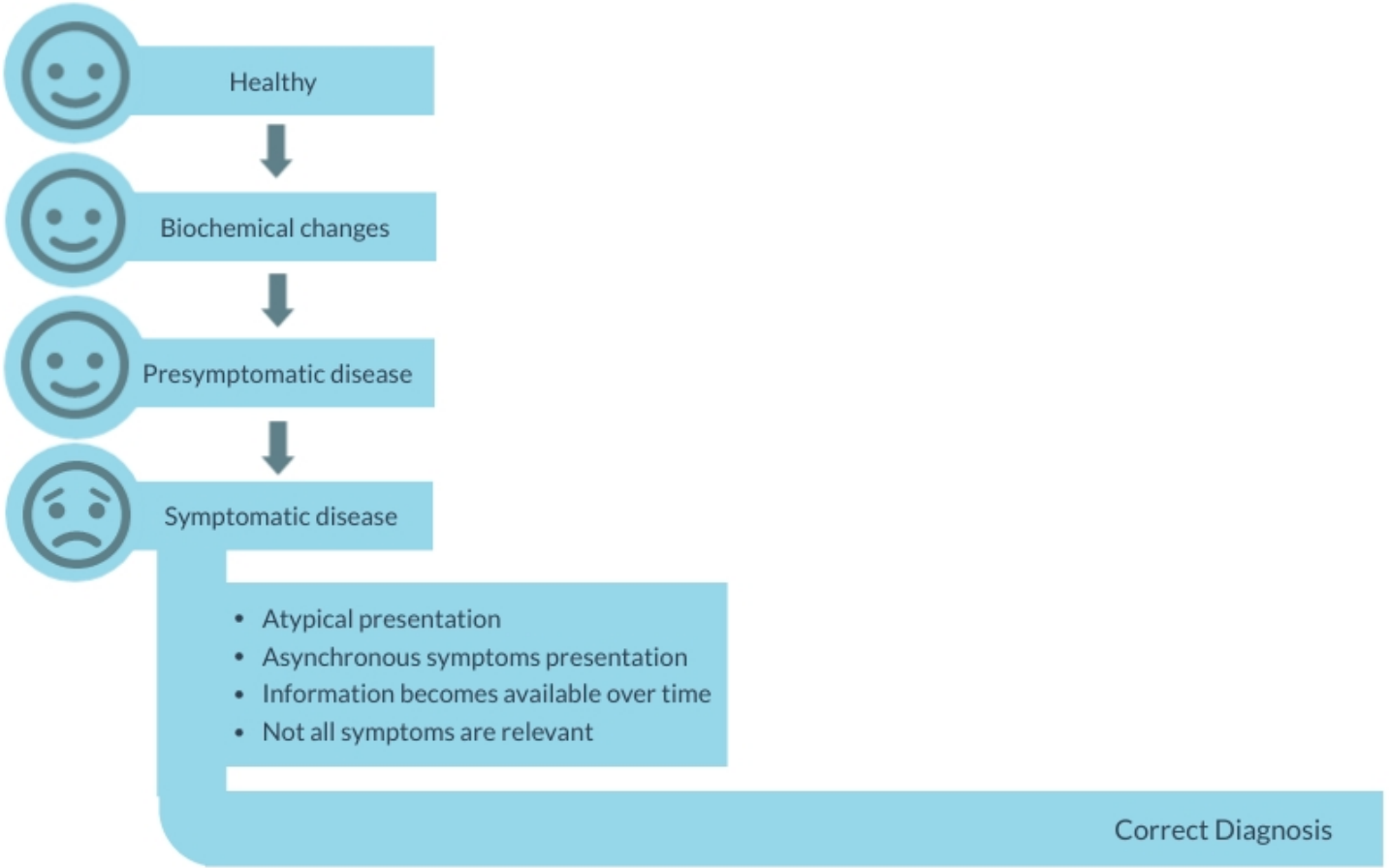
1. A disease evolves over time

2. Balance of overdiagnosis and underdiagnosis

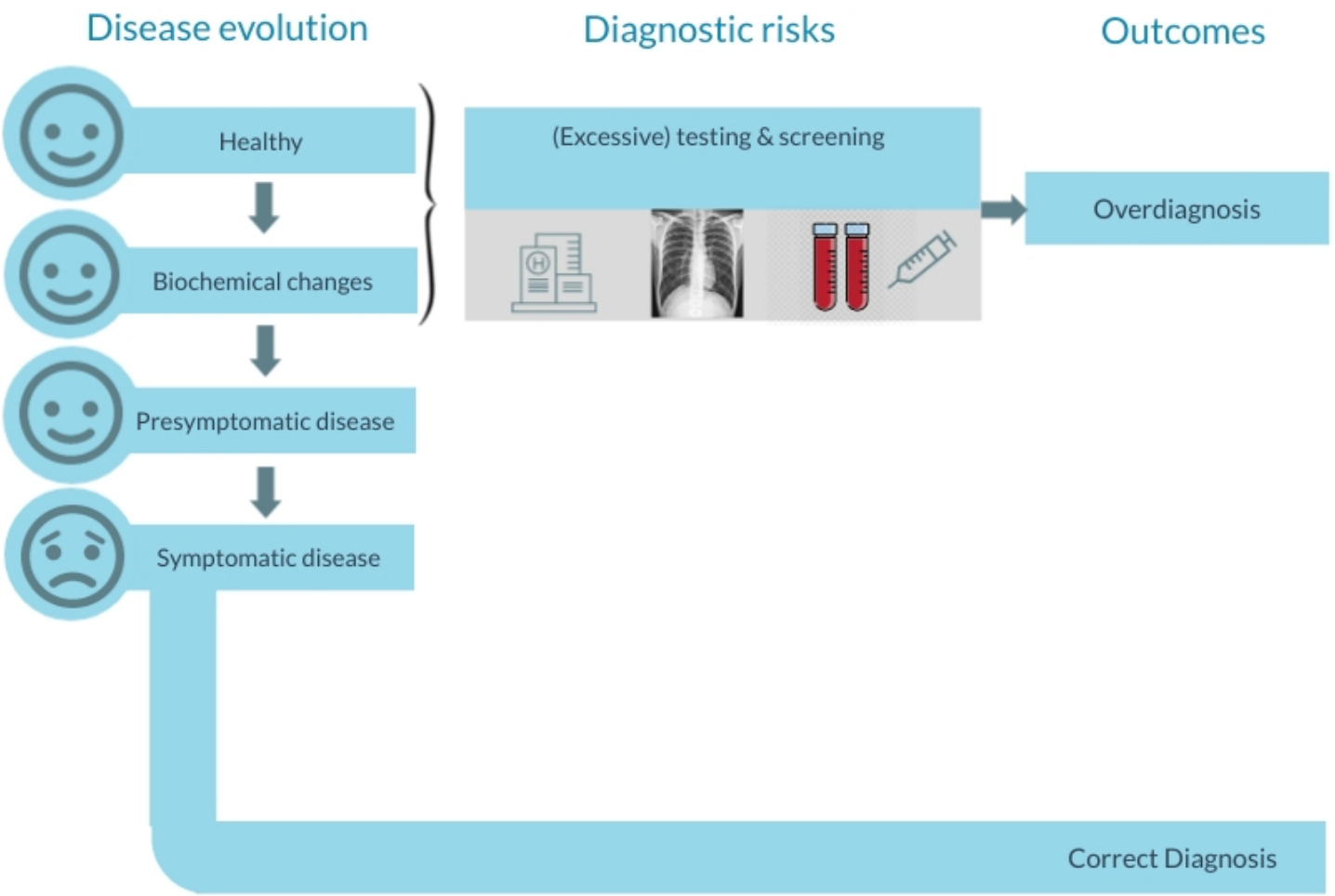
3. Dealing with uncertainty

Challenge 1: Evolving disease

Disease evolution



Zwaan & Singh, Diagnosis, 2015



Zwaan & Singh, Diagnosis, 2015

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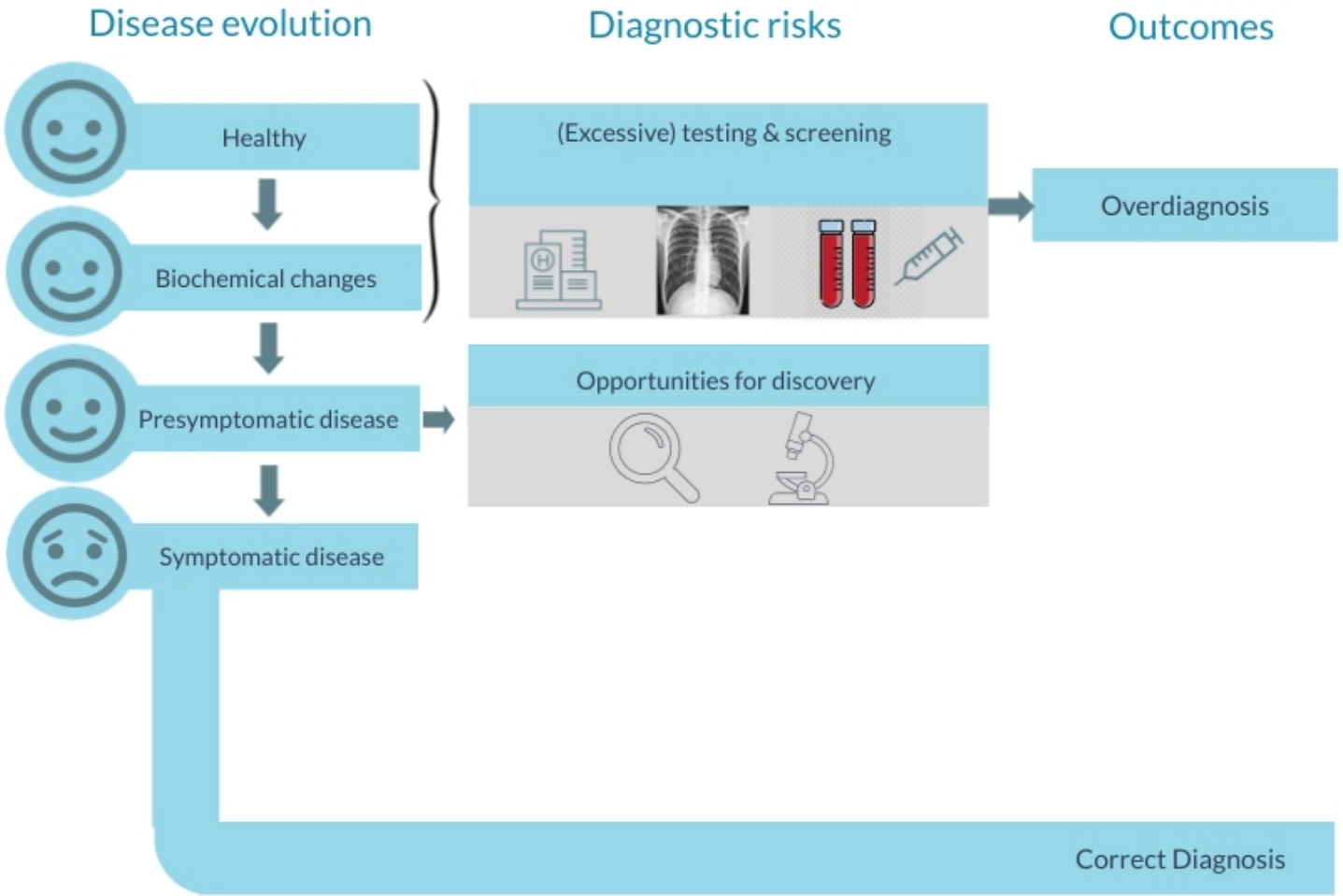

Zwaan & Singh, Diagnosis, 2015

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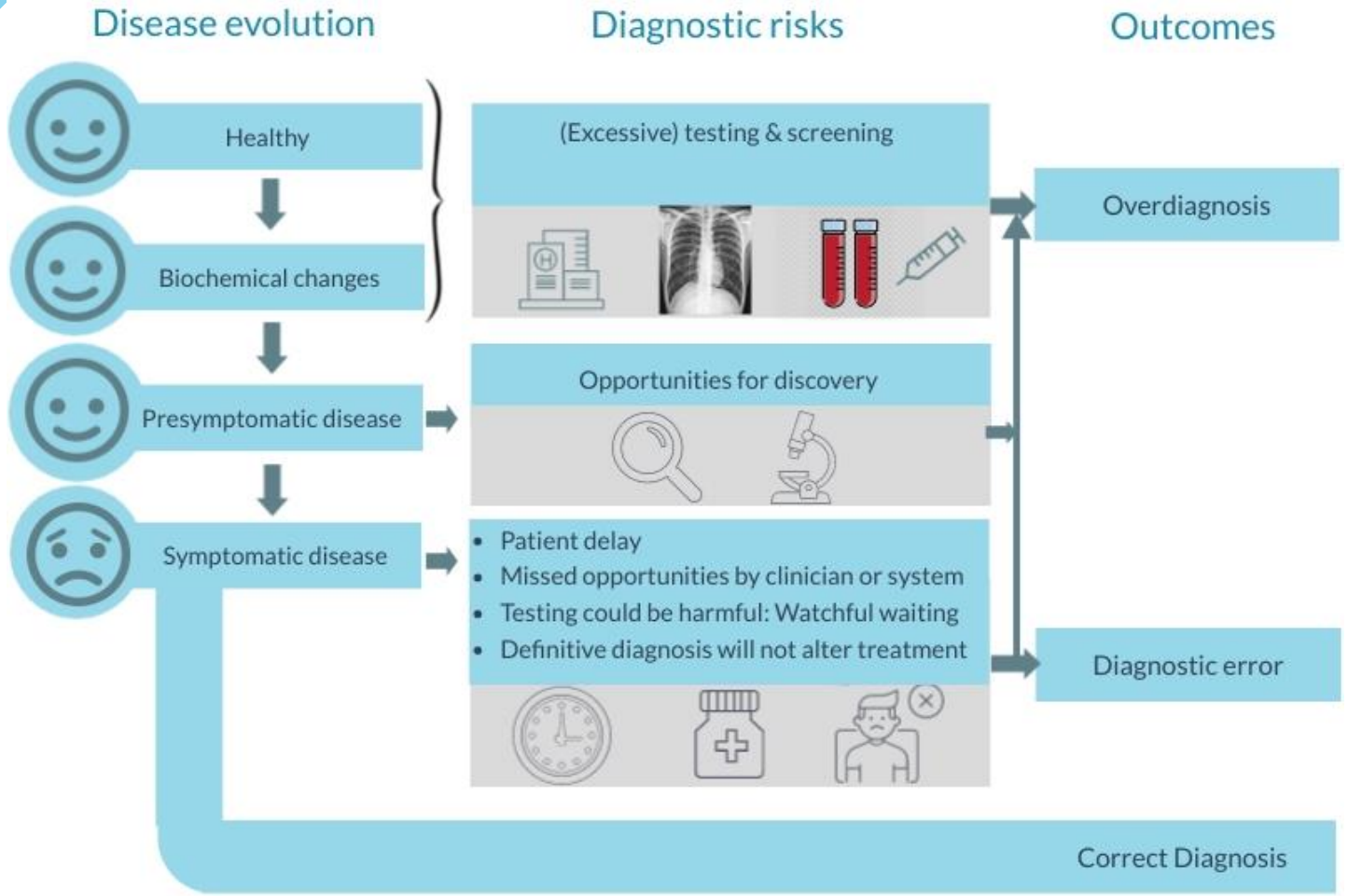

Zwaan & Singh, Diagnosis, 2015

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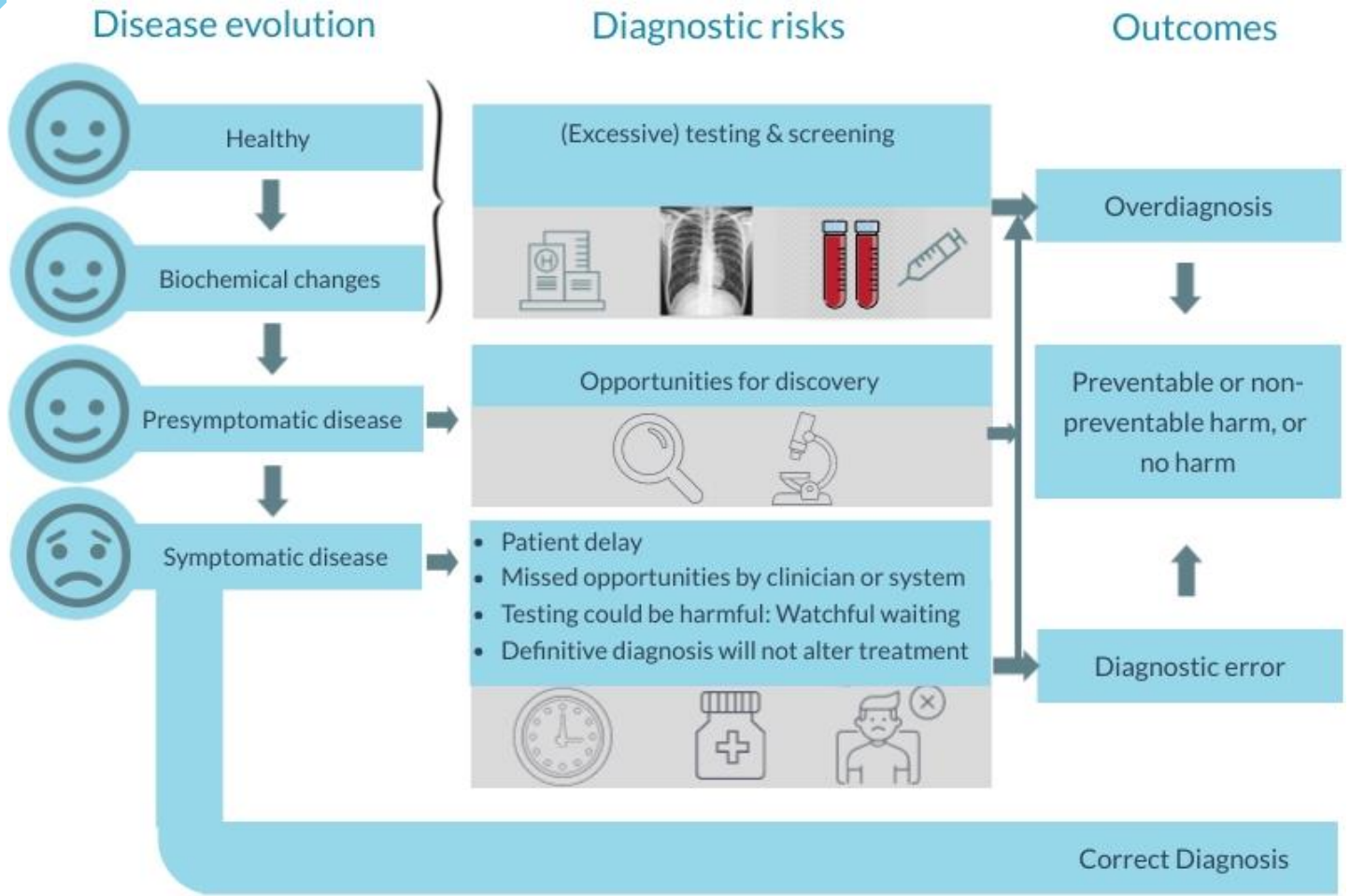
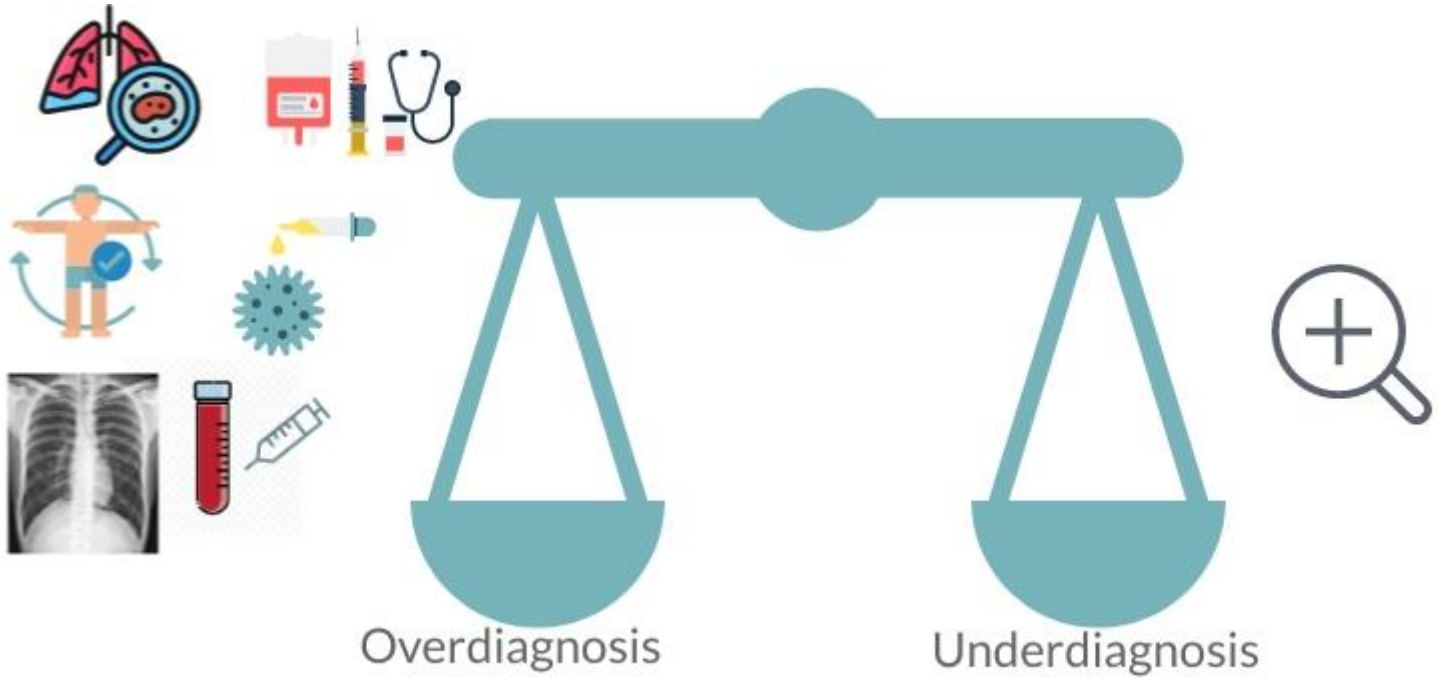


Zwaan & Singh, Diagnosis, 2015

Challenge 2: Balance of overdiagnosis vs underdiagnosis



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Singh, Dickinson et al. Can Fam Physician, 2018
Graber et al. Arch Intern Med, 2005

Challenge 3: Dealing with Uncertainty

Zwaan & Hautz, BMJ Qual Saf, 2019
Meyer et al. JAMA Intern Med. 2013

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Decision making under uncertainty

Types of decision making

- Decision making under certainty
  - The decision maker *knows with certainty* the consequences of every alternative

- Decision making under risk
  - The decision maker *knows the probabilities* of the various outcomes (risk)

- Decision making under uncertainty
  - The decision maker *does not know* the probabilities of the various outcomes

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Decision making under uncertainty

Patient history?

Heart attack?

Pulmonary embolsim?

Family history?

Smoker?

High blood pressure?

Diabetes?

Overweight

Aorta dissection?

Age?

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Zwaan & Hautz, BMJ Qual Saf, 2019

Tolerance of uncertainty

- More junior physicians less tolerant of uncertainty than experts
  - More diagnostic tests

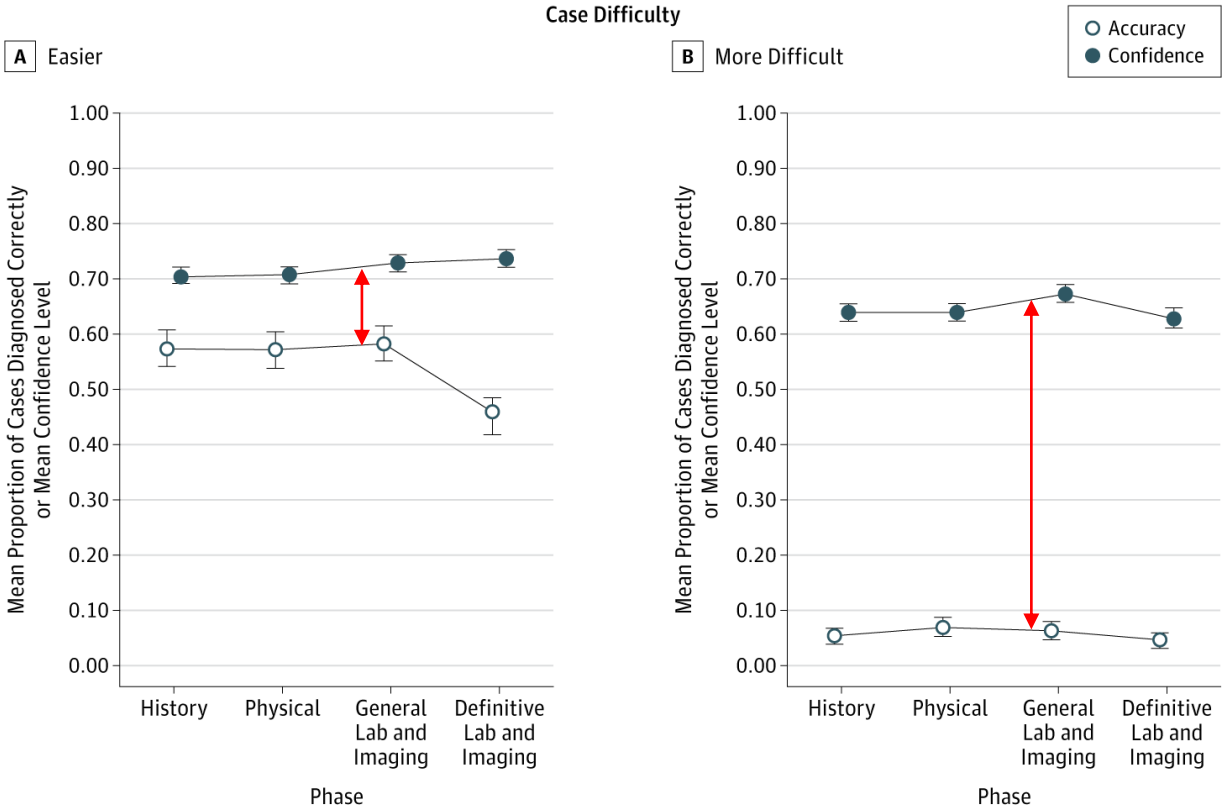
- Experts more tolerant of uncertainty
  - Uncertainty triggers more attentive monitoring

Ilgen et al. Adv in Health Sci Educ. 2018
Lawton et al. BMJ Qual Saf, 2019

Diagnostic calibration

How does the level of certainty correlate with the diagnostic accuracy?

Poor accuracy-confidence calibration



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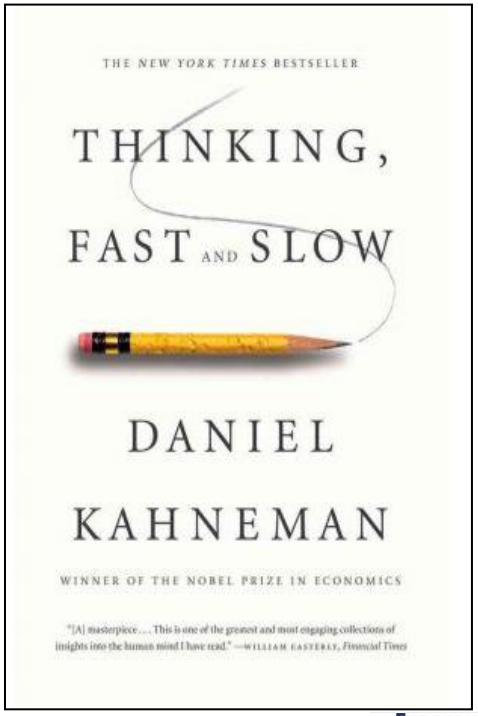
Meyer et al. JAMA Intern Med, 2013

Dual-process thinking

Two different reasoning systems:

- System 1: Heuristic system
- System 2: Analytical system



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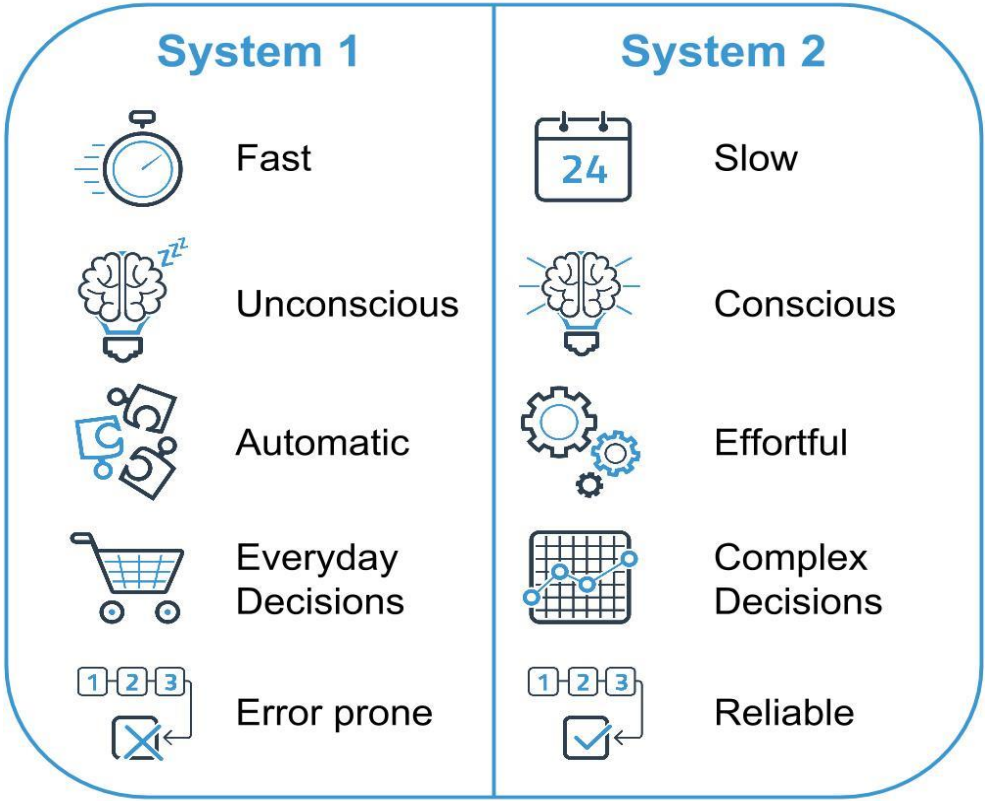
Reasoning modes



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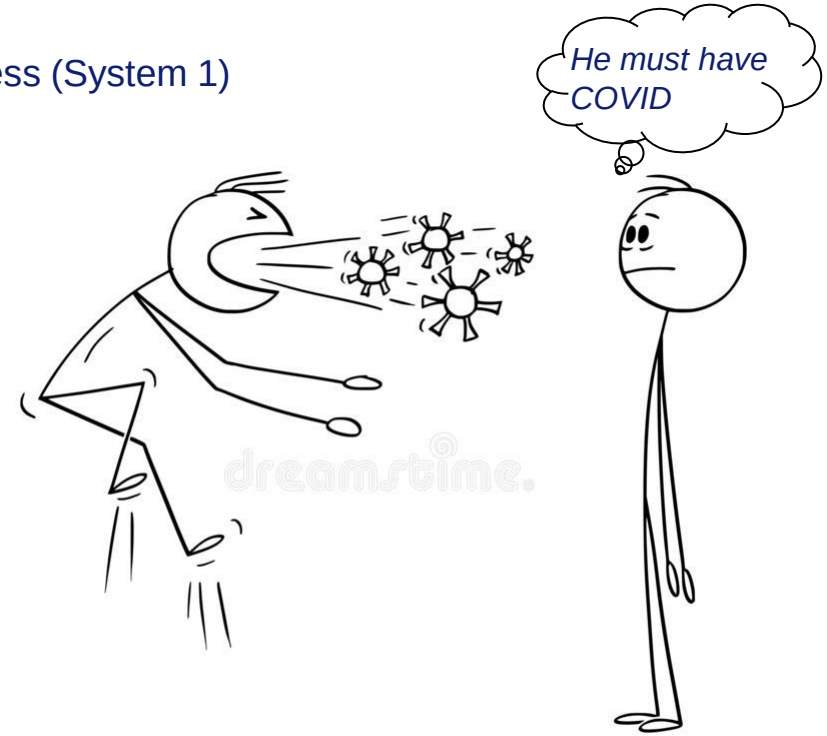
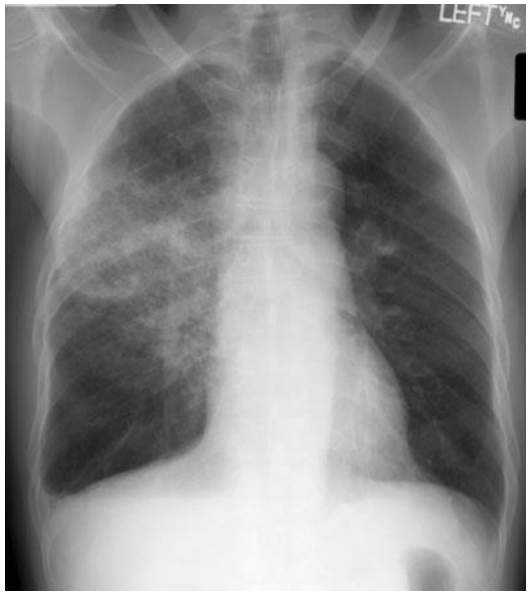
Coping with the challenges

Heuristics: Shortcuts in the reasoning process (System 1)

- Representativeness heuristic
- Availability heuristic



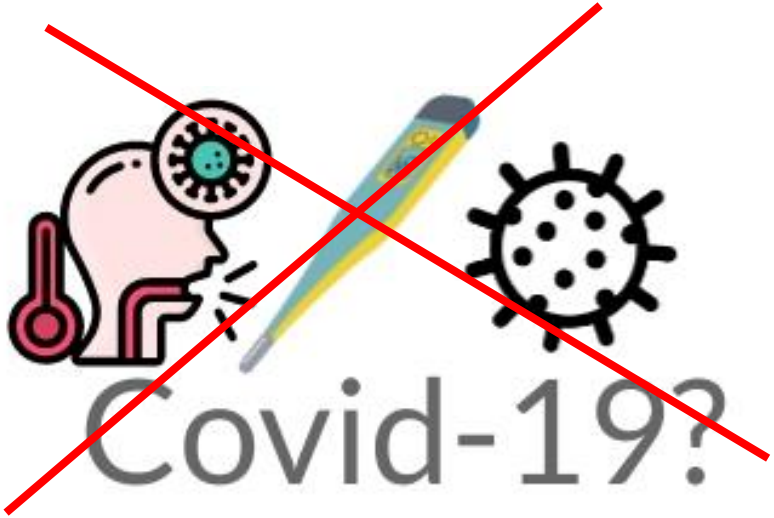
Diagnosing in a split second



Cognitive biases

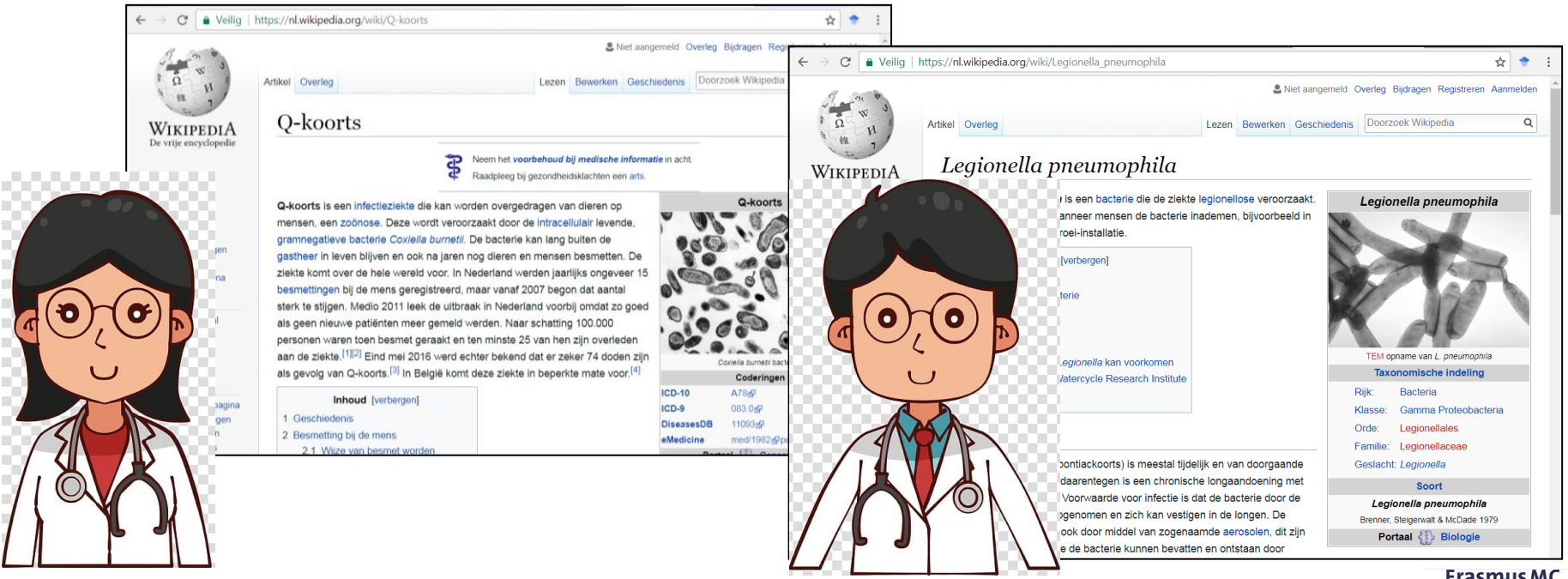
Failed heuristic can result in a cognitive bias

- Representativeness bias
- Availability bias



Availability bias

Phase 1: Availability induced by reviewing a Wikipedia page



Schmidt et al. 2014

Availability bias

Phase 2. Diagnose of 8 clinical cases to determine relevance for education

Q-fever

History of Present Illness
A 43-year old woman was brought to the emergency department by her husband at 0200 in the morning because of shortness of breath. The dyspnea occurred suddenly at 1100 pm and awoke the patient from sleep. This dyspnea was accompanied by retrosternal chest pain, which was worse on deep breathing. She also reports that she had awoken with chest tightness the prior night, but this resolved after a short while. The patient reports that she has been feeling unwell for about 4 days, with throat and sinus congestion, fever and chills, and vomited a small amount of bile. She has also had a cough for several days, and had coughed up small amounts of blood. The patient complained of nausea and vomited a small amount of bile during the triage interview. She has had no recent surgery.

Past Medical History
Tubal ligation, 8 years ago
Pneumonia, 2 years ago
No recent surgery

Social History
Prior smoking; stopped 2 years previously.

Medications
None

Physical examination
Her temp was 37.4, pulse 96, BP 110/96, RR 15.
The chest was clear to auscultation.
The heart sounds were normal as was the abdominal exam.
There was some left calf tenderness without swelling.

Further Testing and Imaging
Her WBC count was elevated (13.0 x 10^9 /L (normal range: 4.5-11.0)).
Her hemoglobin level was normal.
The ECG demonstrates non-specific ST depression in V3-V6.

A Chest X-ray was ordered to diagnose pneumonia.

The chest x-ray demonstrated an opacity in the periphery of her left lower field. The patient was prescribed a course of antibiotics, educated regarding return precautions, and instructed to follow-up with her primary care physician the next 24-48 hours.

Two days later, the patient was seen in the clinic for follow-up with her primary care physician. She reported marked improvement in her chest pain and shortness of breath, as well as resolution of her fevers and chills. She was instructed to complete her course of antibiotics.

Legionnaires disease

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Two days later, the patient was seen in the clinic for follow-up with her primary care physician. She reported continued chest pain and shortness of breath, and several episodes of hemoptysis. A CT Pulmonary Angiogram was ordered to diagnose a pulmonary embolism. This demonstrated a pulmonary embolism in the segmental pulmonary artery of her left lower lobe. A heparin drip was started and the patient was admitted to the hospital.

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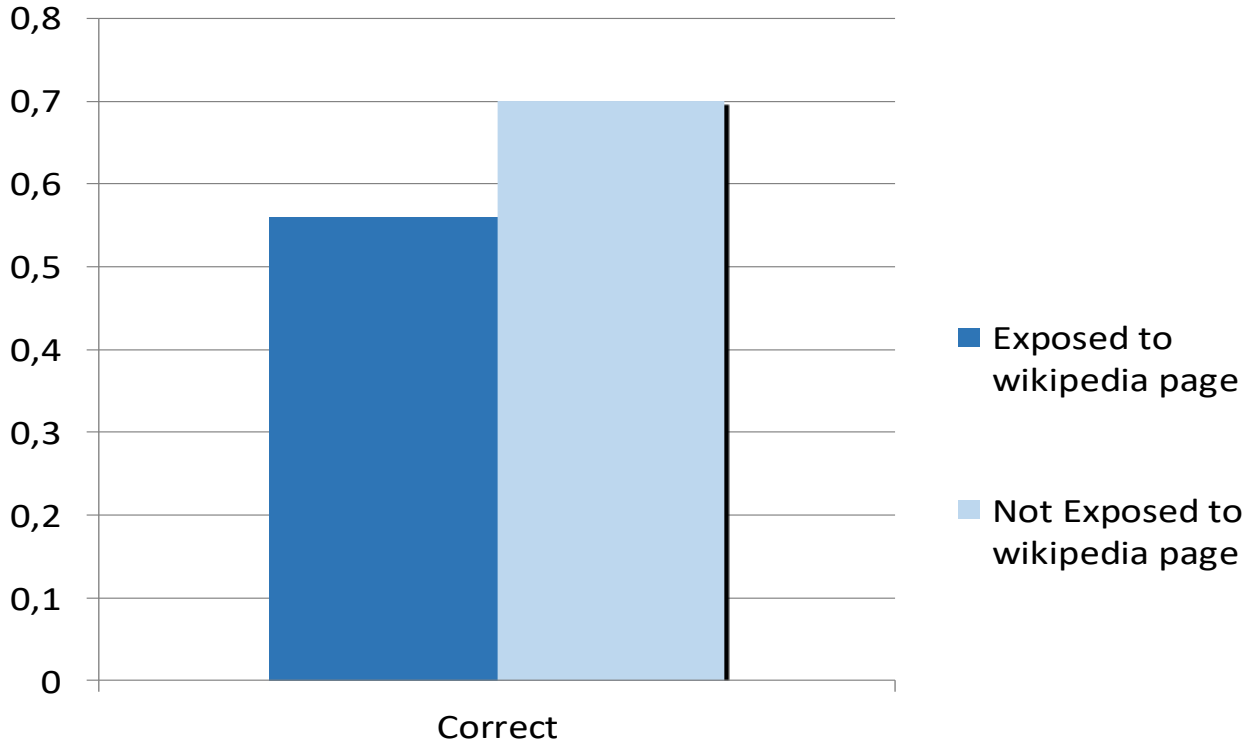
Schmidt et al. 2014

Availability bias - Results



t(37) = 2.52, p= .016

Schmidt et al. 2014

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Base-rate neglect

A psychologist wrote thumbnail descriptions of a sample of 1000 participants consisting of 999 democrats and 1 republican. The description below was chosen at random from the 1000 available descriptions.

Russell is 67 and lives in Georgia. He used to work in the oil business and owns a ranch. He believes in traditional marriage.

Which one of the following two statements is most likely?

a. Russell is a democrat
b. Russell is a republican

De Neys & Glumicic, 2008

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Base-rate neglect

- Relevant for covid testing:
- Patient with high pre-test probability

Test positive: COVID almost certain
Test negative: high chance of COVID

Person with low pre-test probability

Test positive: COVID likely
Test negative: chance of COVID is small

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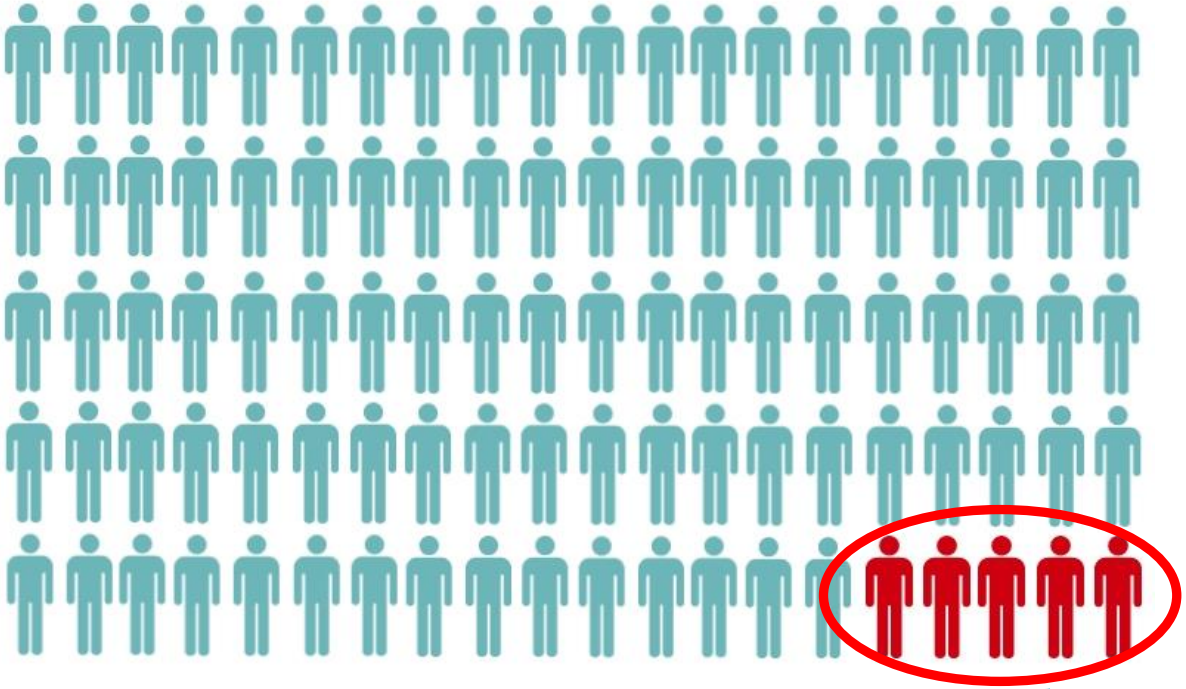
Solutions to bias?

‘Debiasing’

- Be aware about biases
- Reconsider the diagnosis
- Slow down

Analyses of diagnostic error cases only

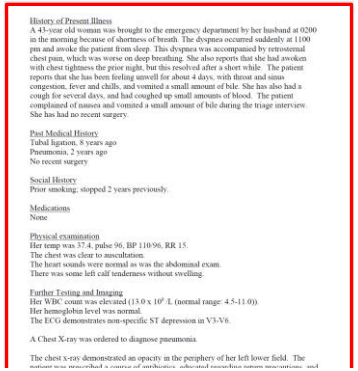


Hindsight bias

Hindsight bias

The effect hightsight on the evaluation of ambigious cases

Half of the participants: consistent outcome



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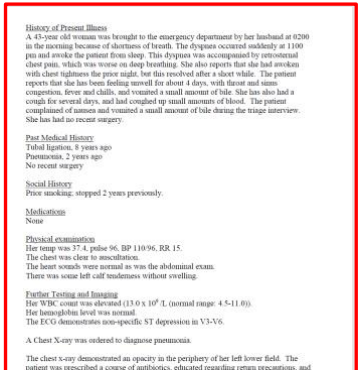
She reported marked improvement in her chest pain and shortness of breath, as well as resolution of her fevers and chills. She was instructed to complete her course of antibiotics.

Diagnostic error? 8% said yes

Half of the participants: inconsistent outcome



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She reported continued chest pain and dyspnea, and several episodes of hemoptysis. A CT Angiogram was ordered, which demonstrated a pulmonary embolism in her left lower lobe. A heparin drip was started and the patient was admitted to the hospital.

Diagnostic error? 60% said yes

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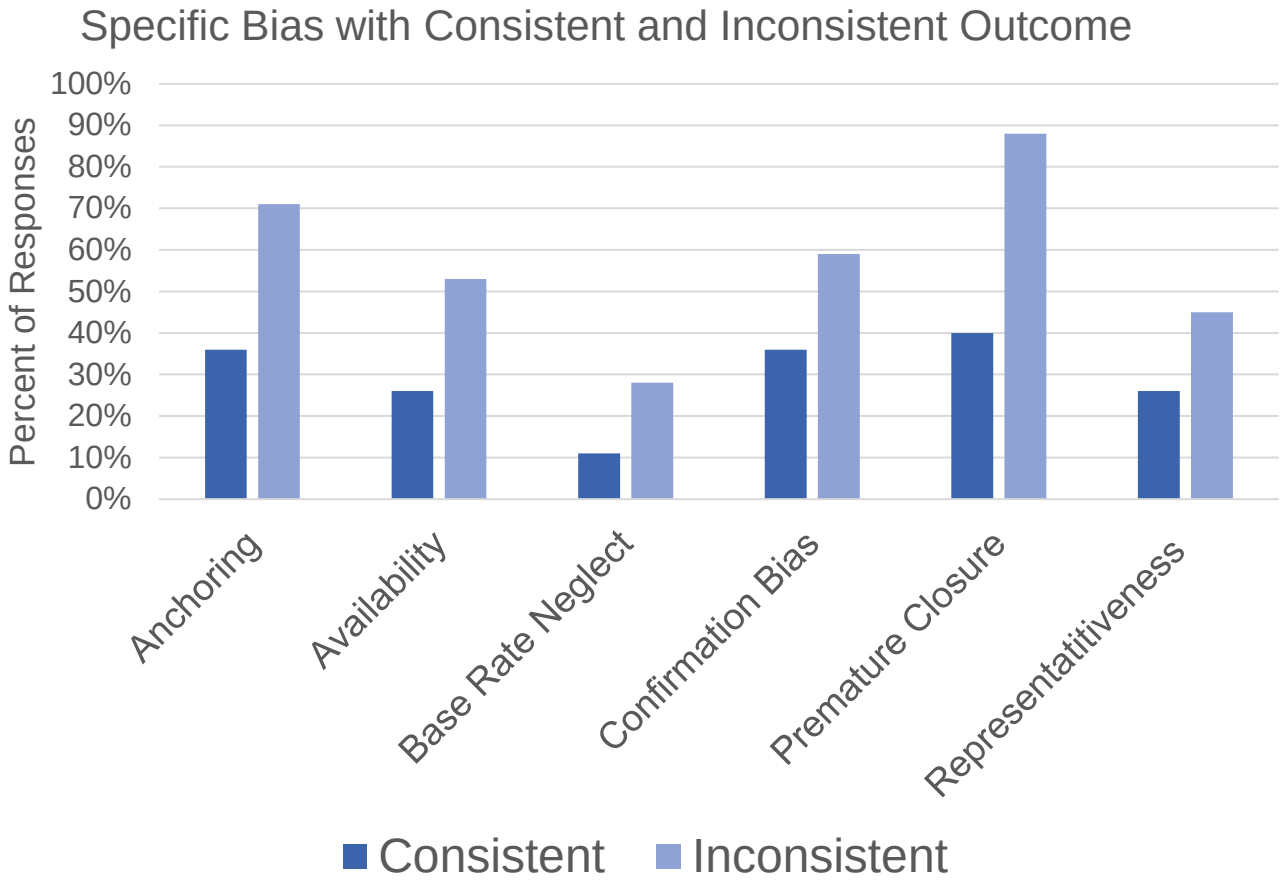


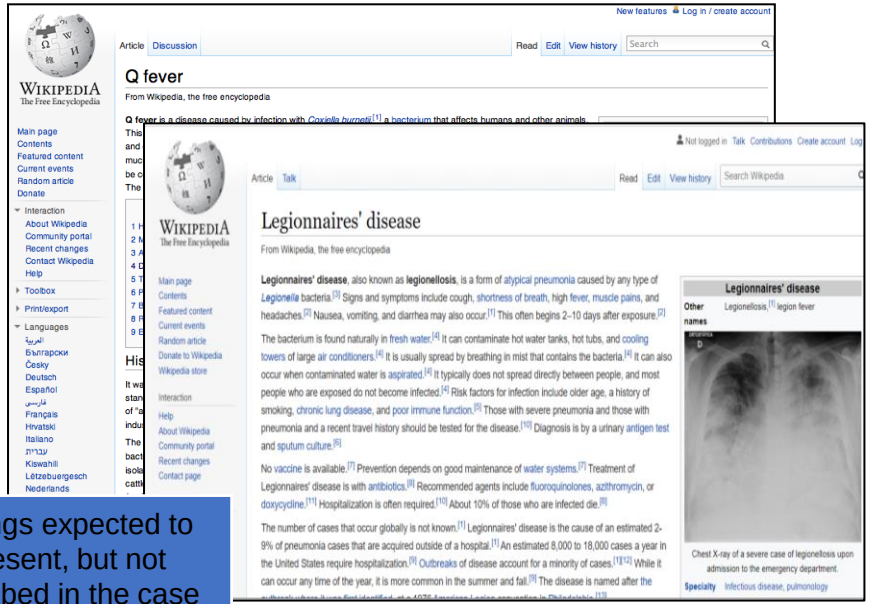
Zwaan et al. BMJ Q&S 2017

Content knowledge to prevent bias

Immunization against bias: Content knowledge-intervention

	Diagnostic hypothesis	Findings that speak in favor of this diagnostic hypothesis	Findings that speak against this diagnostic hypothesis	Findings expected to be present, but not described in the case
1	*Asthma*	*Chest tightness* *Dyspnea* *Cough* *Wheezing* *Attacks after exercise or exposure to allergens* *Remission of symptoms* *Hypoxemia*	*Age of onset* *Without history of allergy* *No family history of asthma*	*Accessory muscles use* *Prolongation of expiratory phase*
3	*Chronic obstructive pulmonary disease (COPD)*	*Attacks triggerred by exercise* *Age of onset middle-age* *Long time smoker* *Dyspnea* *Rhonchi Wheezing* *Hypoxemia*	*Dyspnea and cough: episodic*	*Sputum production* *Chronic, persistent cough* *Respiratory acidosis* *Decreased breath sounds*
2	*Pulmonary embolism*	*Dyspnea* *Wheezing* *Chest tightness* *ECG* *Smoker*	*Non-pleuritic chest pain (tightness)* *Normal respiratory frequency* *Jugular veins: no abnormalities*	*Tachypnea* *Hemoptysis* *History of risk factors for DVT (immobilization etc.)*

Availability bias induction



Diagnostic Hypothesis	Findings that speak in favor of this diagnostic hypothesis	Findings that speak against this diagnostic hypothesis	Findings expected to be present, but not described in the case

Mamede et al. BMJ Qual Saf, 2020

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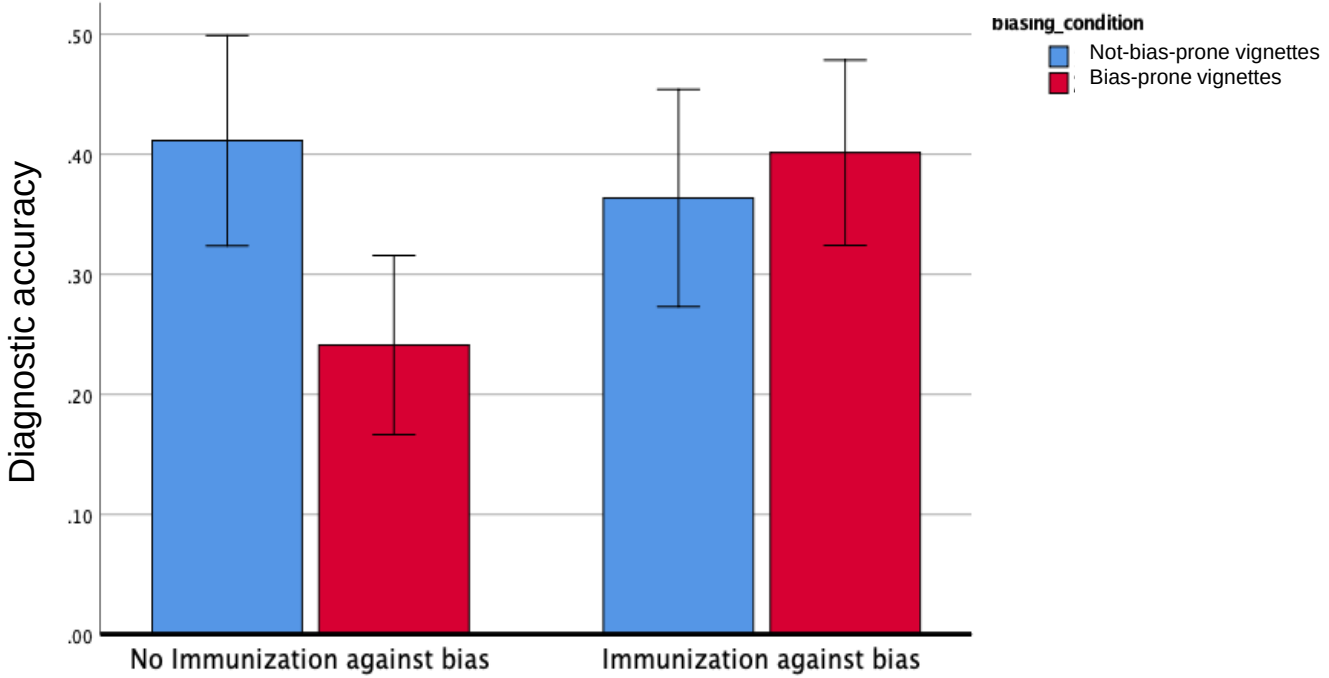
Content knowledge prevents availability bias



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Content knowledge and outcomes

- Measurement of diagnostic knowledge on board exam (N=1410)
- Diagnostic outcomes were measured per 1000 visits (48.632 visits)

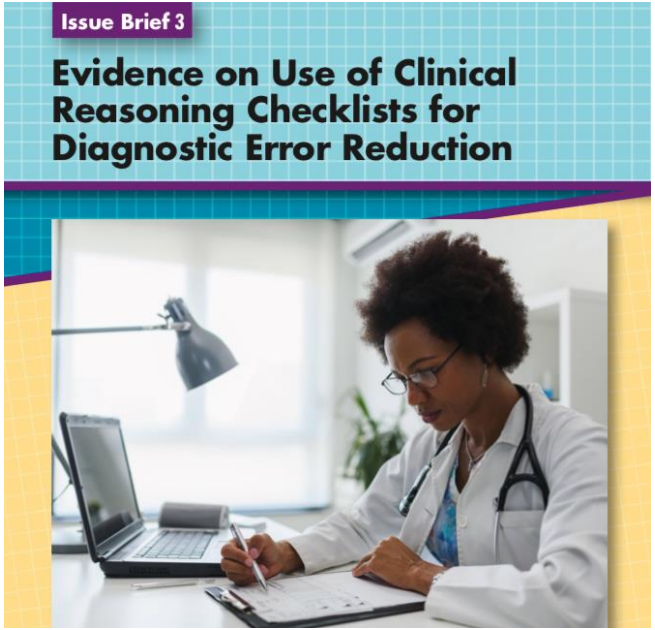
- Differences between highest-lowest third:
  - 2.9 fewer deaths
  - 4.1 fewer hospitalizations
  - 4.9 fewer ED visits

Grey et al. BMJ Open, 2021

Knowledge is key

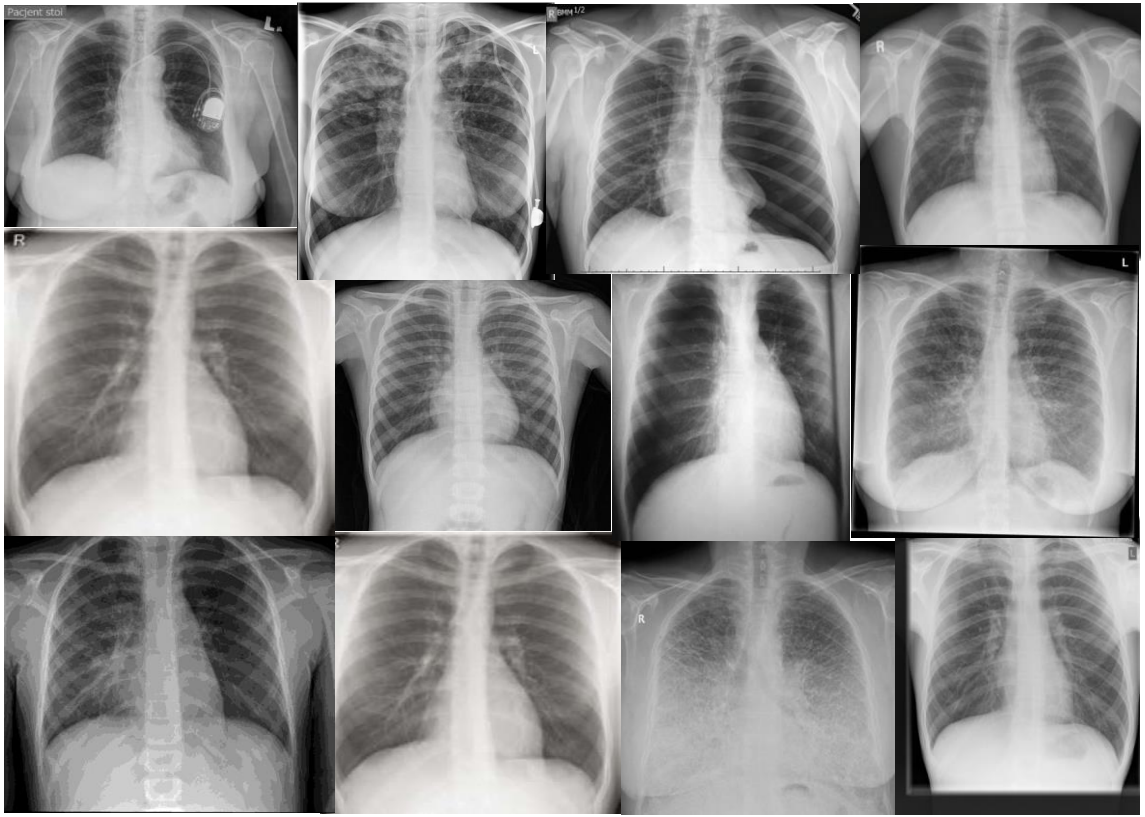
- Correct and extensive knowledge representations are key

- Little/no effect:
  - General debiasing (awareness of biases)
  - General checklists (slow down, reconsider)



Zwaan & Staal, AHRQ brief, 2020

Seeing many examples



Zwaan et al, in prep

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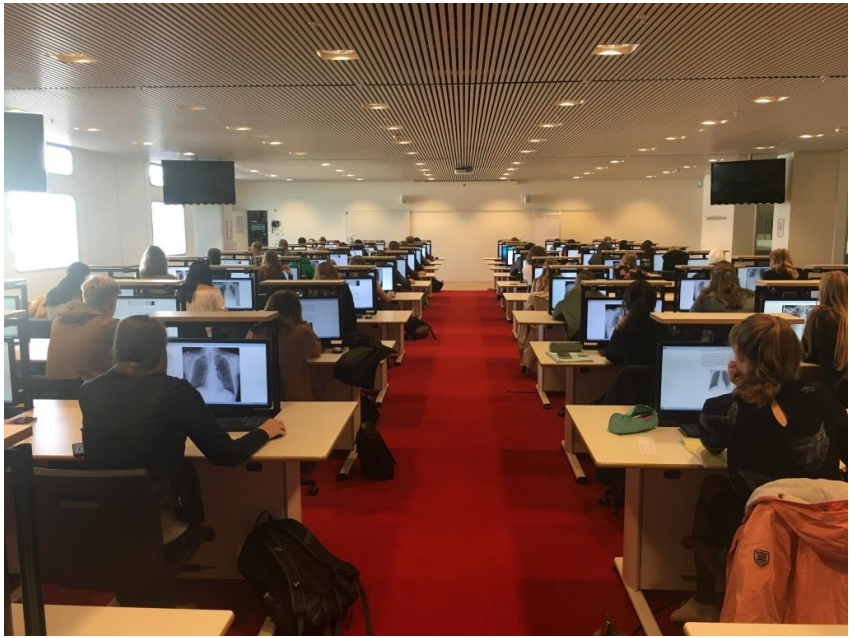
Seeing many examples



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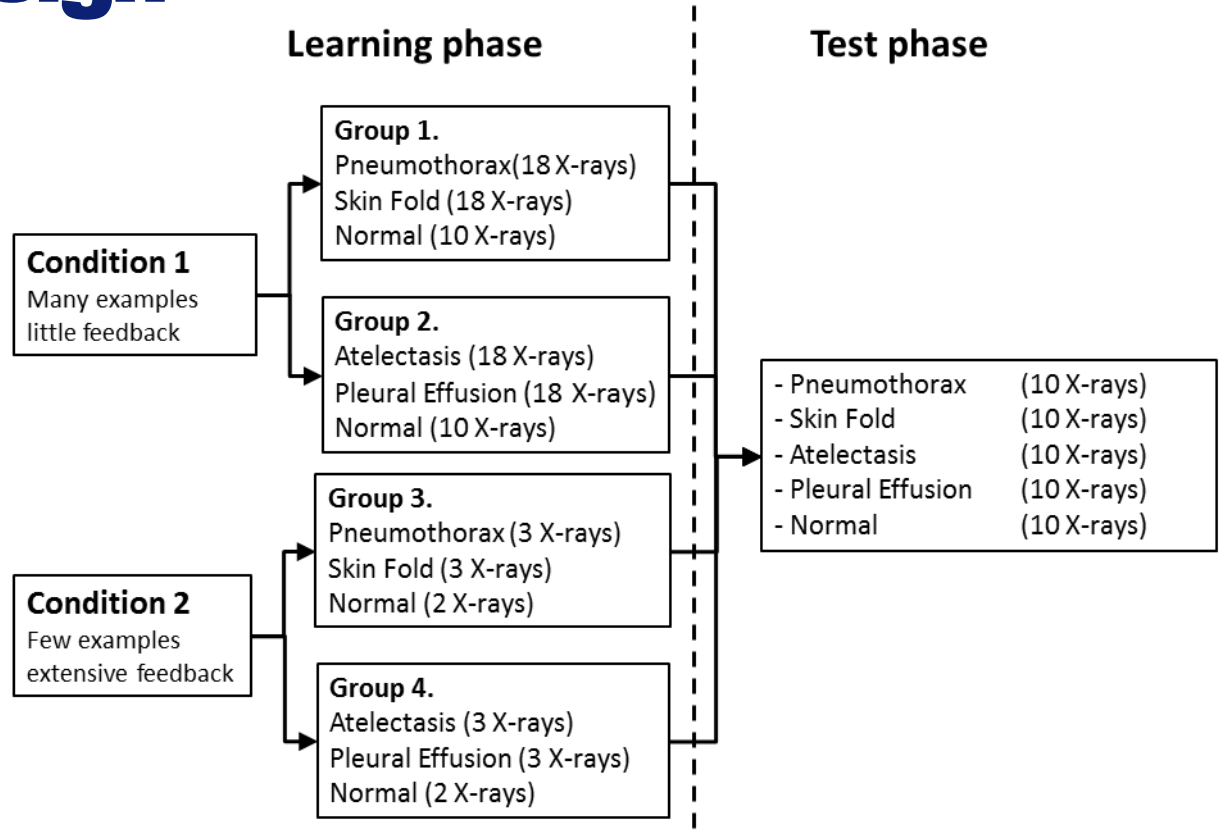
Design



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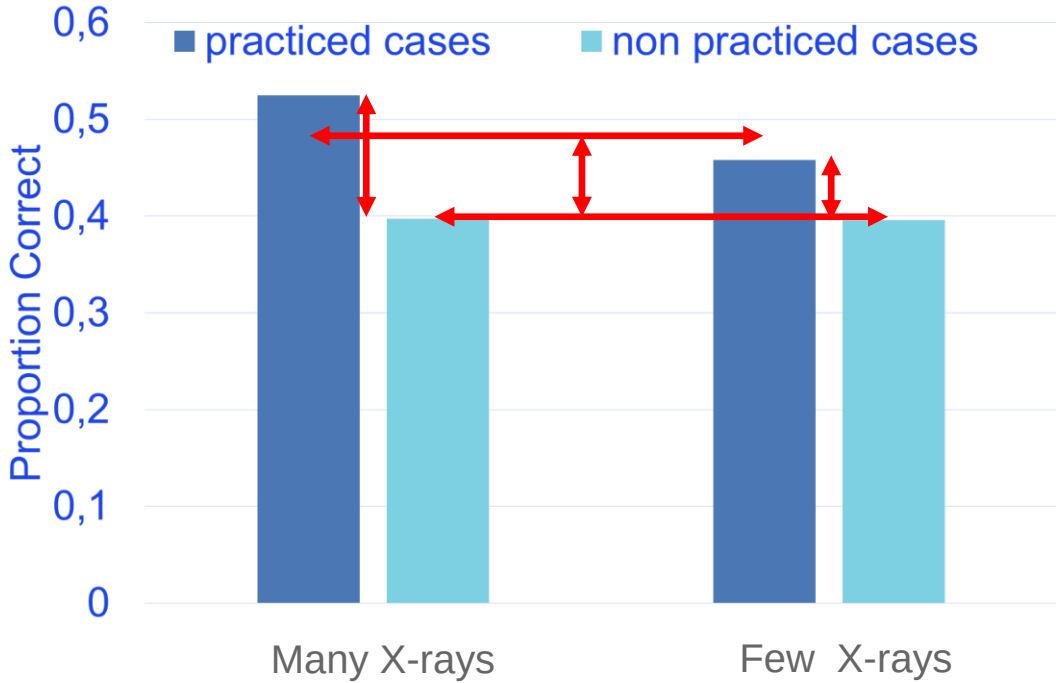
Practice with many examples



- *No difference on cases not practiced with*
- *Significant main effect of practice F=56,196, p<0.001*
- *Significant interaction effect F=6.652, p <0.05*

Zwaan et al, in prep

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How to improve diagnostic safety?

- Content specific feedback
- Practice with many examples and distinguishing features
- Collaboration with artificial intelligence

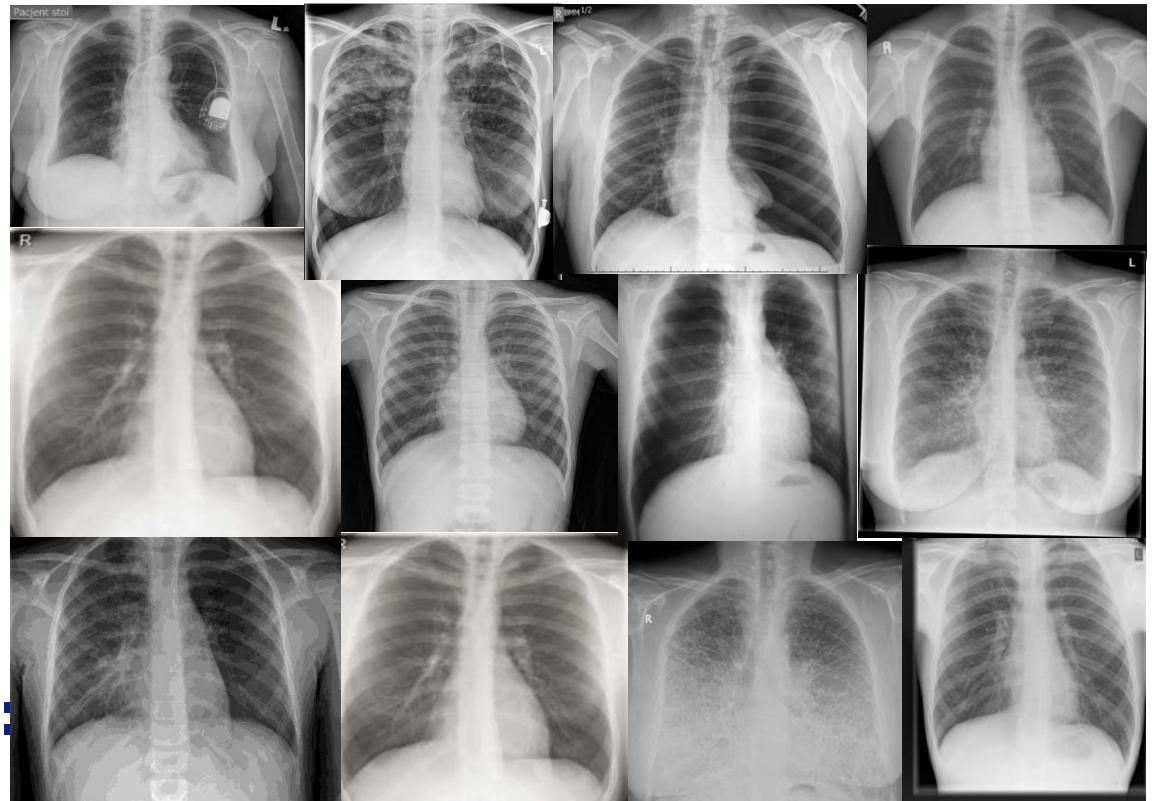
Increase content specific feedback

Physician seeing a patient → Outcomes

Practice with many examples and distinguishing features

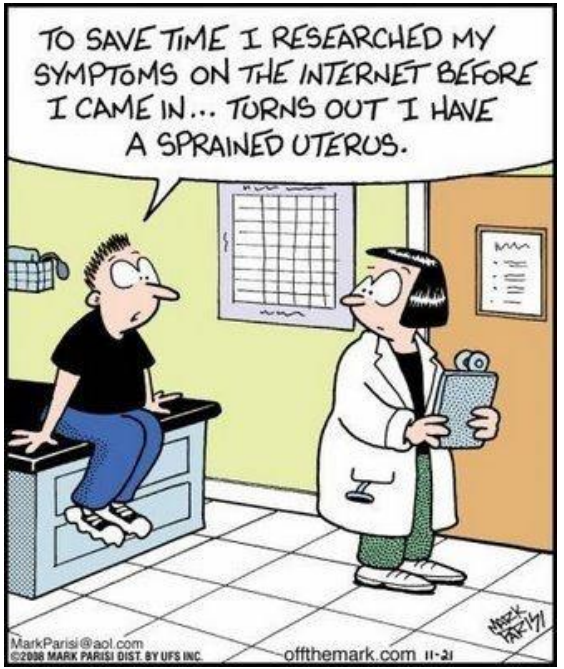
1 case

Many cases



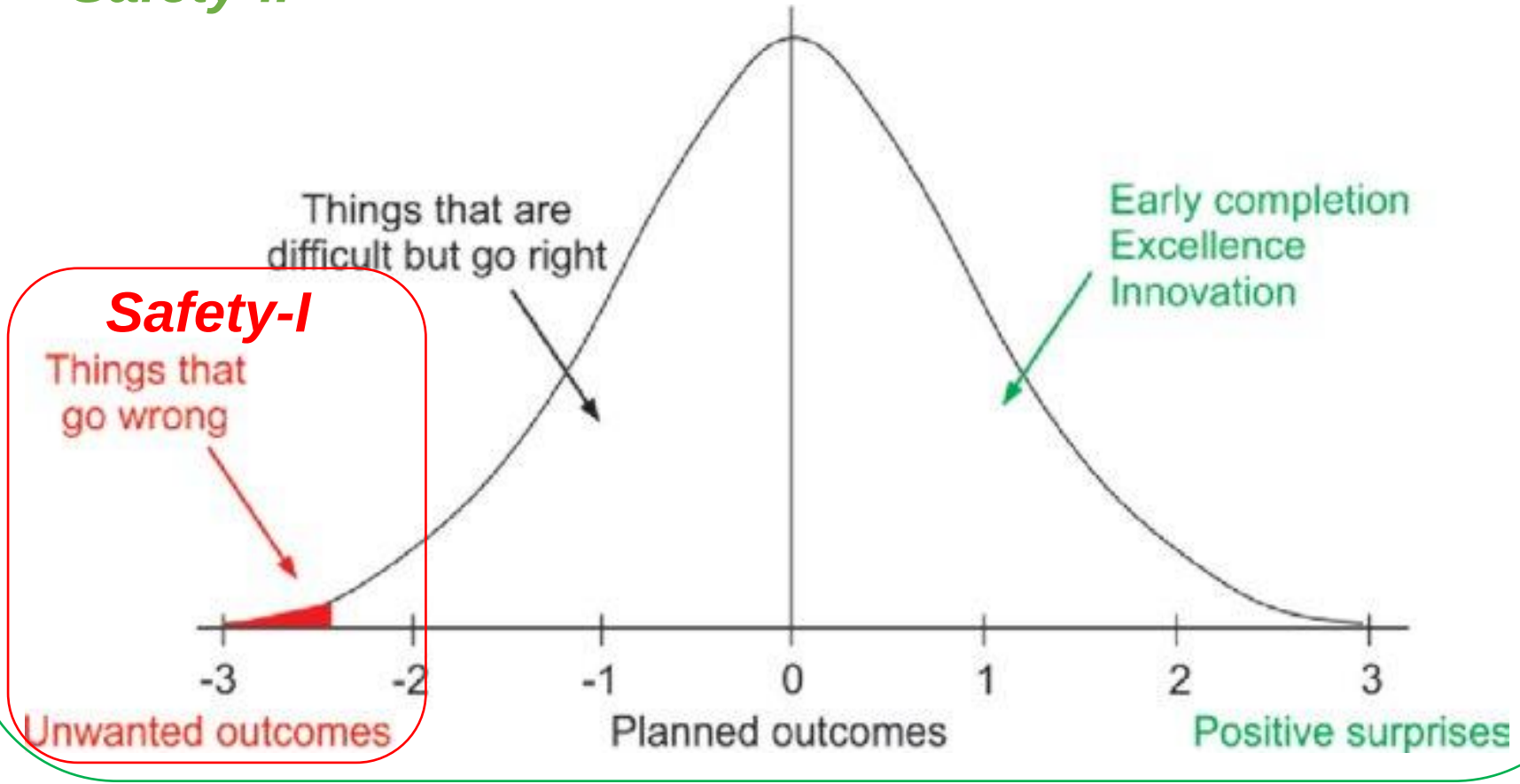
Collaboration with artificial intelligence

- AI is very promising for improving diagnosis
- Computers make different mistakes than humans
- Current lack of understanding how to implement AI in the diagnostic process



Safety-II approach

Safety-II



Hollnagel, Wears & Braithwaite, 2015

Why do things go right?

Because healthcare professionals are flexible and adapt to the conditions of work

Why do things go right?

Work-as-Imagined (WAI)

- Rules, procedures, and standard that outline how healthcare professionals should work.

Work-as-Done (WAD)

- How healthcare professionals actually carry out the work.

Work as imagined

Work as done

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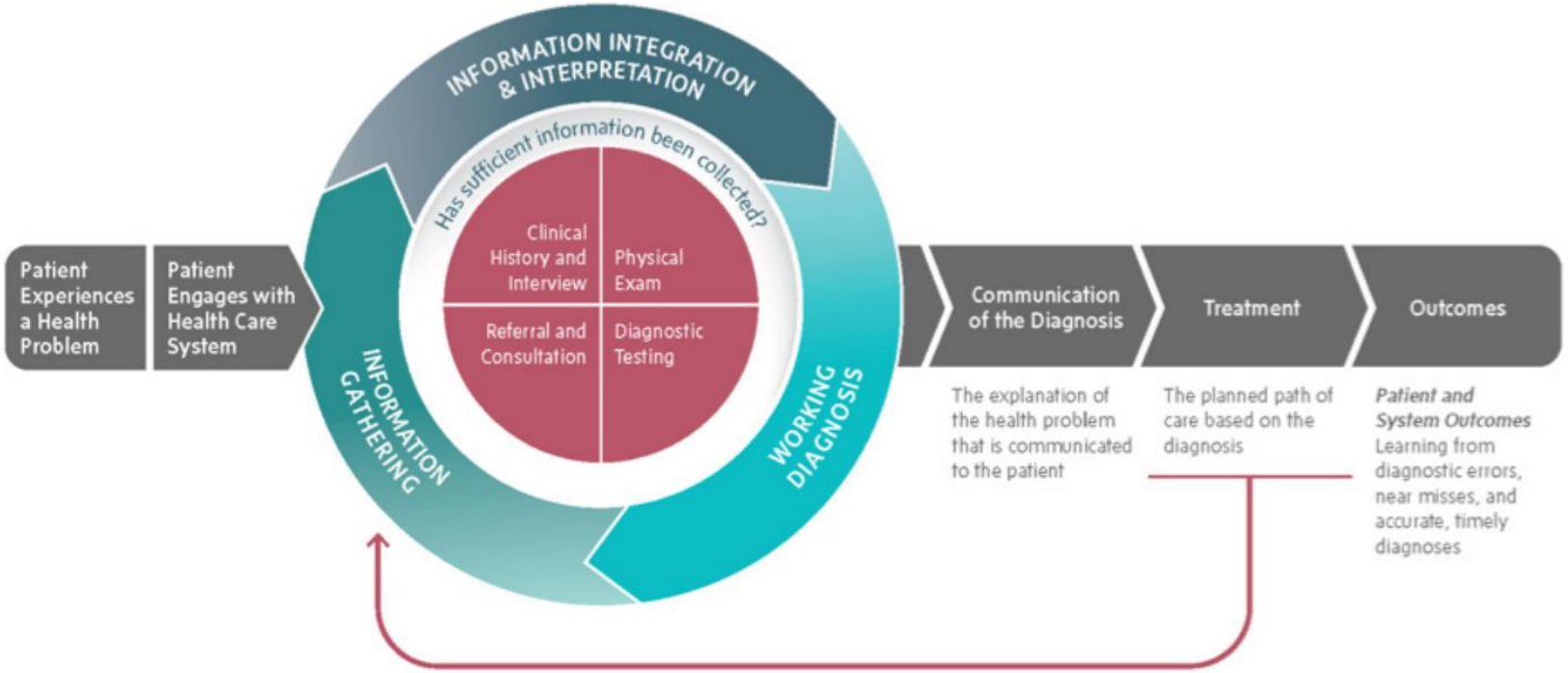
People can adapt

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

Diagnostic process: WAI



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Safety-II

- Safety-II: as many things as possible go right
- Aim: to become an understanding of how things usually go right
- Solution: to facilitate everyday work

Safety-II: an example project

- Goal: explore Safety-II in the diagnostic process

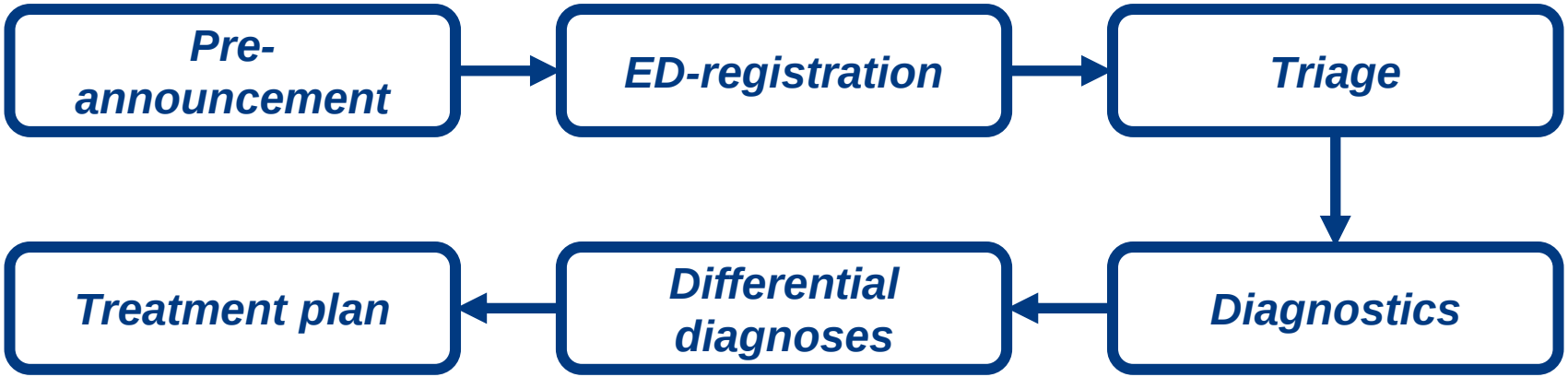
- Emergency department:
  - Complex/adaptive
  - Resilience of clinicians
  - Practice variation

Safety-II example

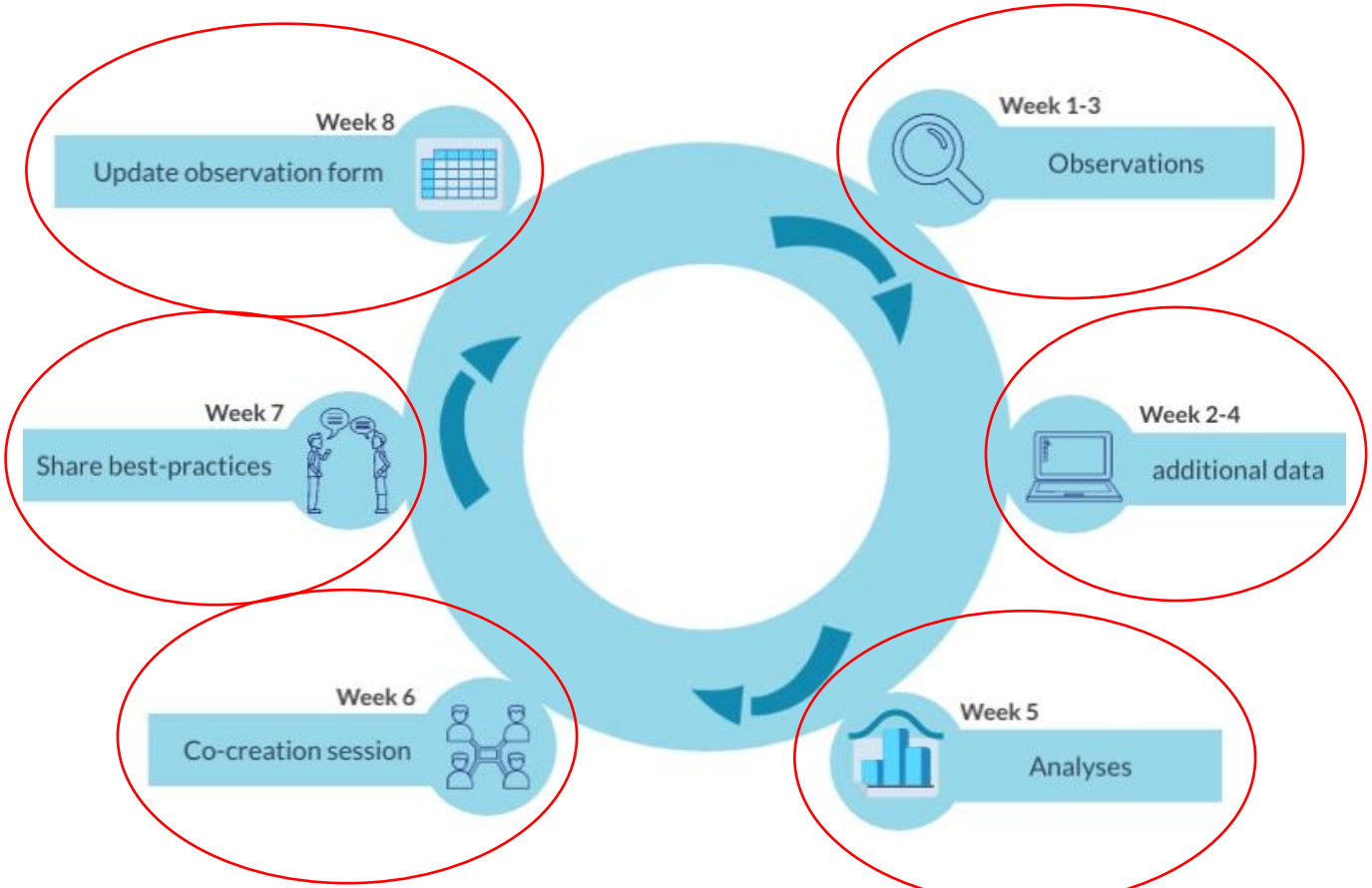
- Action research:
  - Three observation cycles
- Inclusion criteria:
  - 18 years or older
  - Non-specific symptoms
  - Referral for Internal Medicine or ED
- Exclusion criteria:
  - Consultations from other specialisms

Method

- Observation tool
- Dutch care system



Action research



Practice variation

#1 *Internist calls to announce a patient and makes a note in the electronic health record. Medical history: diabetes. Patients has fatigue, flu-like symptoms and prolonged diarrhea. Hypotension (82/47 mmHg). At ED: anamnesis, physical exam, laboratory, blood gas, urine testing, X-thorax and COVID-test.*

#2 *Internist calls to announce a patient. The patient is struggling with shortness of breath for years, now progression since 1 week. Yesterday saturation 98%. No improvement after start furosemide, for which referral.*

Co-creation

Erasmus MC

Implementation of improvement

- Successful 7:
  - Referrer:
  - Reason for ED-presentation:
  - Core of story:
  - Relevant medical history / medication:
  - Differential diagnoses:
  - Intended follow-up process:
  - Code status:

Practice variation

- We observed that a diagnosis was sometimes made earlier when the required laboratory tests were specified upon arrival:
  - Ordering of additional tests
  - Taking of extra blood samples

- Intended diagnostics is added to Successful 7.

Our experiences

- Safety-II approach is particularly suitable for the diagnostic process
- Stimulating positive behavior eases implementation
- Learning culture

Limitations

- Concepts not yet operationalized
- Measurement of effectiveness remains unclear
- Safety-I and Safety-II overlap

Conclusions

- The diagnostic process is complex
  - A disease evolves over time
  - Balance of overdiagnosis and underdiagnosis
  - Dealing with uncertainty

- Heuristics are used in the diagnostic process
  - These may result in biases
  - Content specific knowledge crucial in diagnostic reasoning

- Content specific interventions are needed to improve the diagnostic reasoning process
  - Feedback
  - Practice with differentiating features and many examples
  - Future role of AI
- Safety-II as a new promising approach to improving diagnosis

Erasmus MC

Save the date SIDM Europe
July 3-4, 2023, Utrecht, The Netherlands

DIAGNOSTIC REASONING AND DIAGNOSTIC ERROR IN MEDICINE

November 29, 2022

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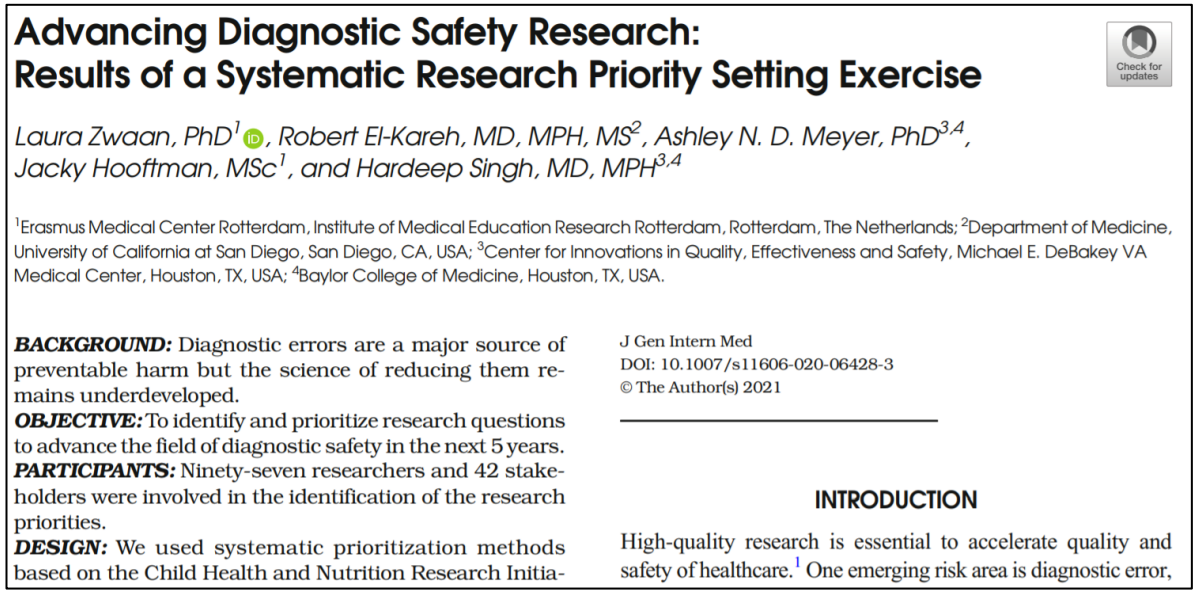
Priorities for diagnostic error reduction

- Identified research priorities to reduce diagnostic safety



Advancing Diagnostic Safety Research: Results of a Systematic Research Priority Setting Exercise

Laura Zwaan, PhD[1], *Robert El-Kareh, MD, MPH, MS*[2], *Ashley N. D. Meyer, PhD*[3,4], *Jacky Hooftman, MSc*[1], *and Hardeep Singh, MD, MPH*[3,4]

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BACKGROUND: Diagnostic errors are a major source of preventable harm but the science of reducing them remains underdeveloped.
OBJECTIVE: To identify and prioritize research questions to advance the field of diagnostic safety in the next 5 years.
PARTICIPANTS: Ninety-seven researchers and 42 stakeholders were involved in the identification of the research priorities.
DESIGN: We used systematic prioritization methods based on the Child Health and Nutrition Research Initia-

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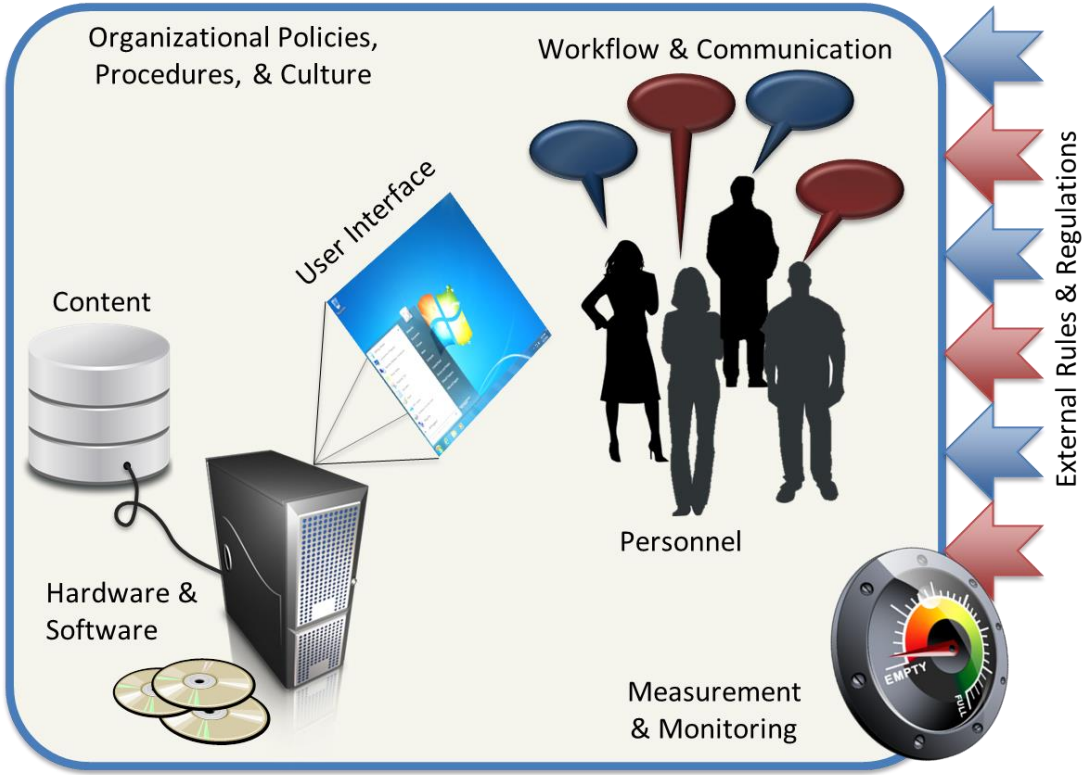
DOI: 10.1007/s11606-020-06428-3

INTRODUCTION

High-quality research is essential to accelerate quality and safety of healthcare.[1] One emerging risk area is diagnostic error,

Other possible interventions



Sittig & Singh, Qual Saf Health Care, 2010