Gníomhaireacht Bainistíochta an Chisteáin Náisiúnta
National Treasury Management Agency

An Ghníomhaireacht um Éilimh ar an Stát
State Claims Agency

Diagnostic Safety in Emergency Departments – State of Science

Professor Prashant Mahajan

Professor of Emergency Medicine and Pediatrics, University of Michigan Medical School

#SCALearning25

How Safe Are Emergency Departments?

Prashant Mahajan MD MPH MBA
William G Barsan Collegiate Chair,
Professor of Emergency Medicine and Pediatrics
Department of Emergency Medicine
University of Michigan
Ann Arbor

Date: 10/01/2025

What do we know about Diagnostic Safety?

We know .....

Fundamental aspect of Patient-Provider Interaction

Complex Cognitive Task Under Uncertainty


spinal
shoulder
human
back
comfort
product
physiology
comfort design
syndrome
injury
work
industrial
productivity
working
stress
headache
accident
sitting
bone
performance
industrial design
psychology
biomechanics
well-being
business
medical
wrong
functional design
employee
workplace
therapeutic
designing
human factors
people factor
engineering
professional
spine
anthropometry
body
office
health
ergonomics
interaction
design
neck
backache
position
ergonomy
strain
activity
designing
products
anatomy
pain
posture
safety
optimizing
study
functional
human body
seated
tension
proper
chair
function
sick


ART

What do we know about Epidemiology of Diagnostic Errors?

We know .....

A Medical Crisis

BELOW THE SURFACE

Surgical & Medication Errors

Diagnostic Errors

5% of outpatien office visits

10% of hospital inpatient deaths

12% of hospital adverse events

74,000 deaths each year

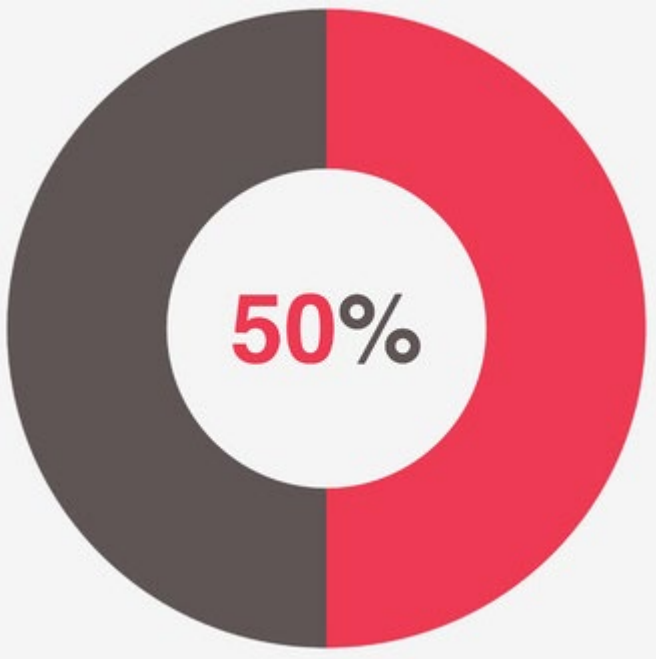
18 MILLION

diagnostic **ERRORS** each year

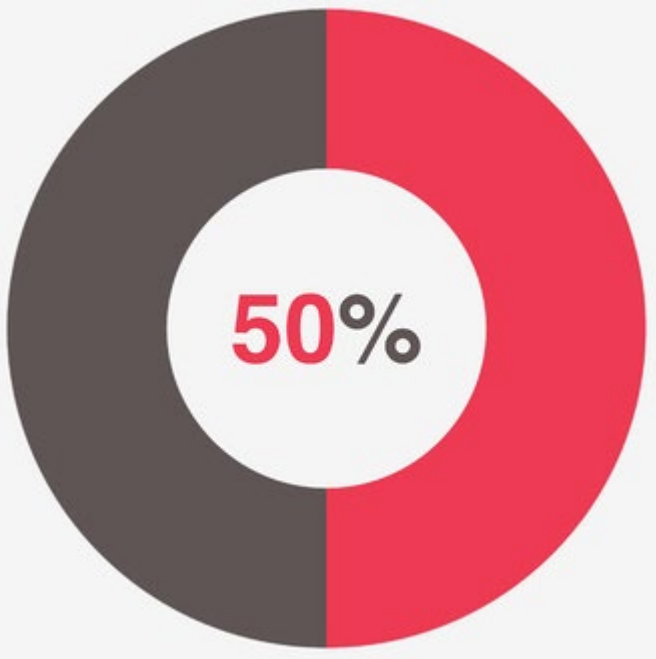
"Nearly every person will experience a **diagnostic error** in their lifetime"

INSTITUTE OF MEDICINE SEPT 2015

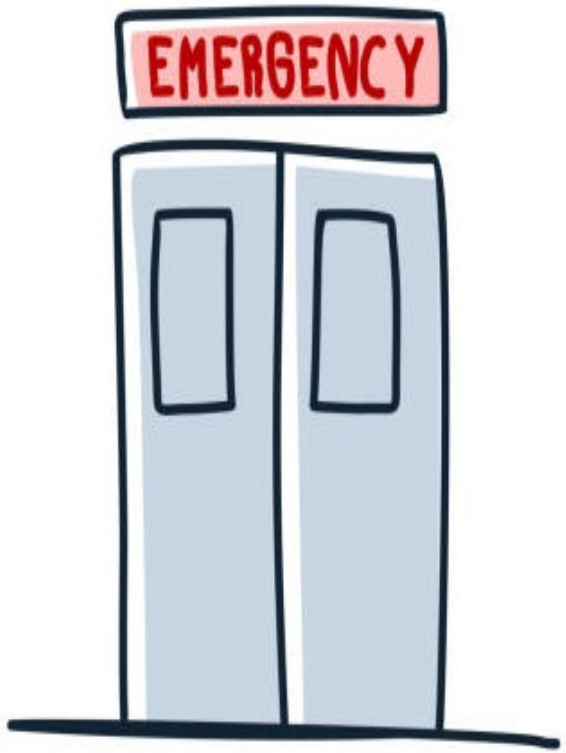
HARM



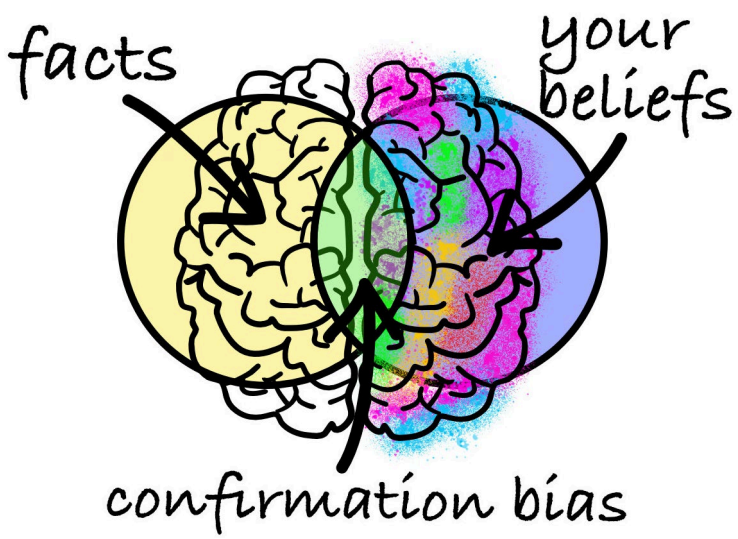
PREVENTABLE



What do we know about Diagnostic Safety and the ED?



EMERGENCY ROOM



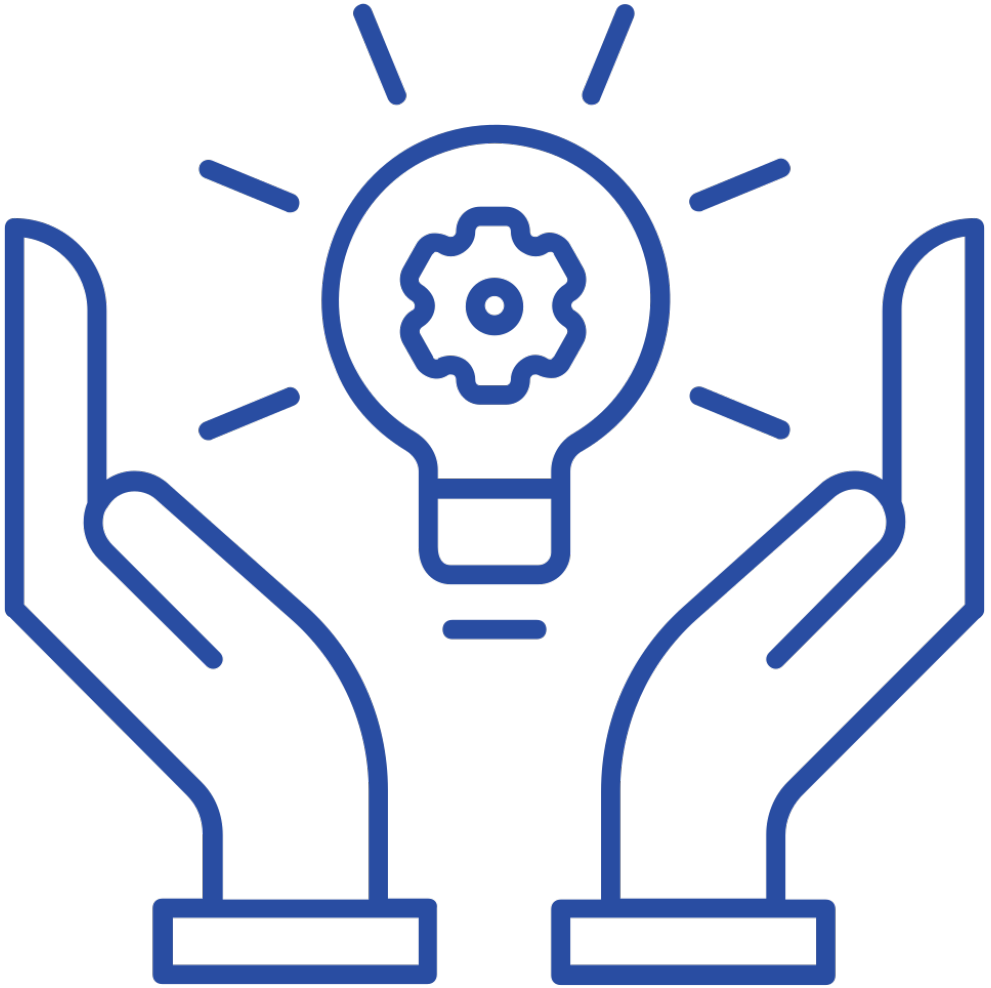
In numbers……

1 in 18 ED patients receiving an incorrect diagnosis,
1 in 50 suffering an adverse event, and
1 in 350 suffering permanent disability or death.

130 million emergency department (ED) visits per year in the United States that
7.4 million (5.7%) patients are misdiagnosed,
2.6 million (2.0%) suffer an adverse event as a result, and about
370,000 (0.3%) suffer serious harms from diagnostic error.

Average ED with 25,000 visits annually
1,400 diagnostic errors,
500 diagnostic adverse events, and
75 serious harms, including
50 deaths per ED.

How Safe Are Emergency Departments?



Improving the Future of Diagnostic Safety

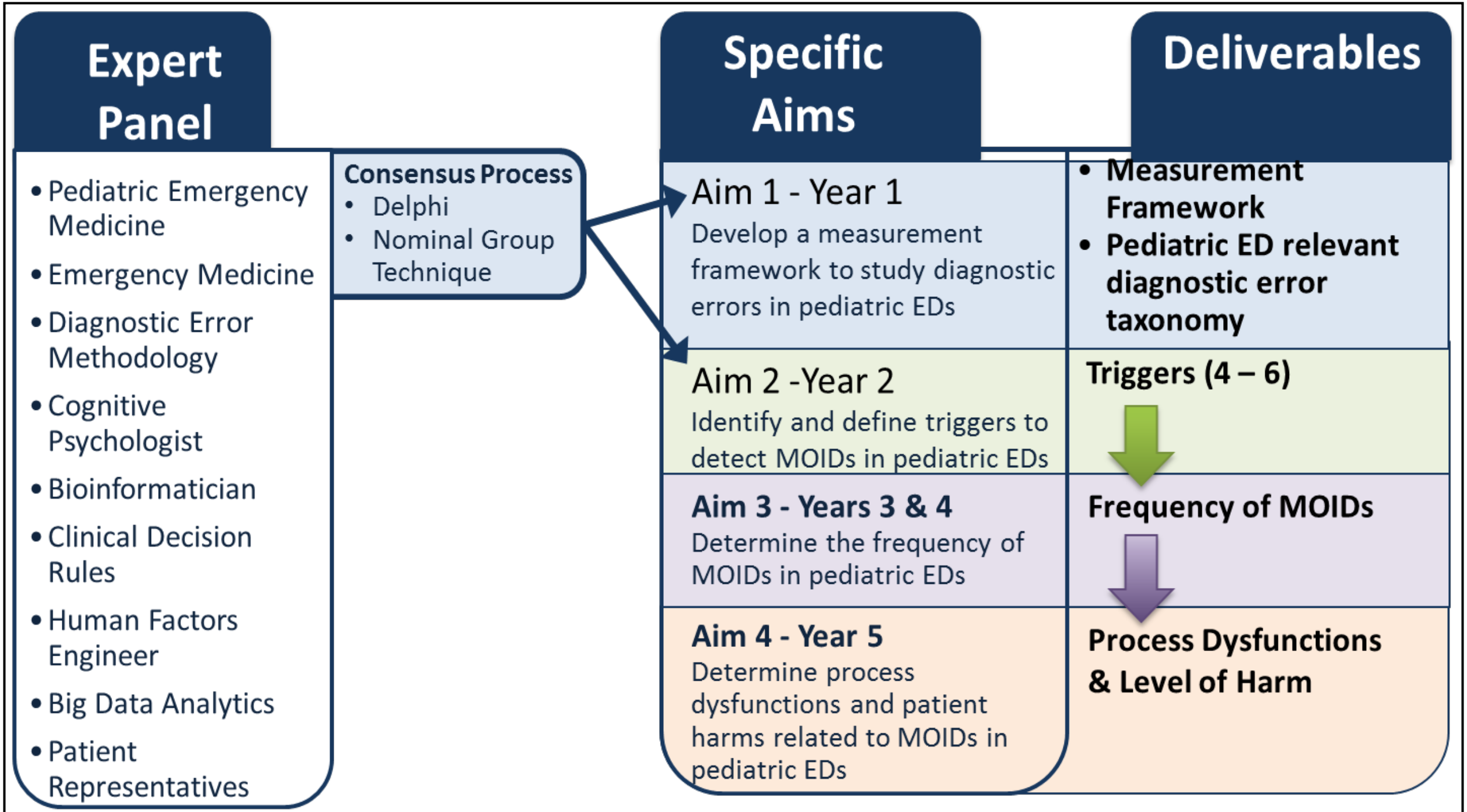
Aims – Pediatric EDs

Aim 1: Develop a measurement framework to study DEs.

Aim 2: Identify and define triggers to detect DEs.

Aim 3: Implement triggers to determine the frequency of DEs.

Aim 4: To determine process dysfunctions and harms from DEs.


Expert Panel
Pediatric Emergency Medicine
Emergency Medicine
Diagnostic Error Methodology
Cognitive Psychologist
Bioinformatician
Clinical Decision Rules
Human Factors Engineer
Big Data Analytics
Patient Representatives
Consensus Process
Delphi
Nominal Group Technique
Specific Aims
Aim 1 - Year 1
Develop a measurement framework to study diagnostic errors in pediatric EDs
Aim 2 -Year 2
Identify and define triggers to detect MOIDs in pediatric EDs
Aim 3 - Years 3 & 4
Determine the frequency of MOIDs in pediatric EDs
Aim 4 - Year 5
Determine process dysfunctions and patient harms related to MOIDs in pediatric EDs
Deliverables
Measurement Framework
Pediatric ED relevant diagnostic error taxonomy
Triggers (4 – 6)
Frequency of MOIDs
Process Dysfunctions & Level of Harm

Aims – Pediatric EDs

Aim 1: Develop a measurement framework to study DEs.

Aim 2: Identify and define triggers to detect DEs.

Aim 3: Implement triggers to determine the frequency of DEs.

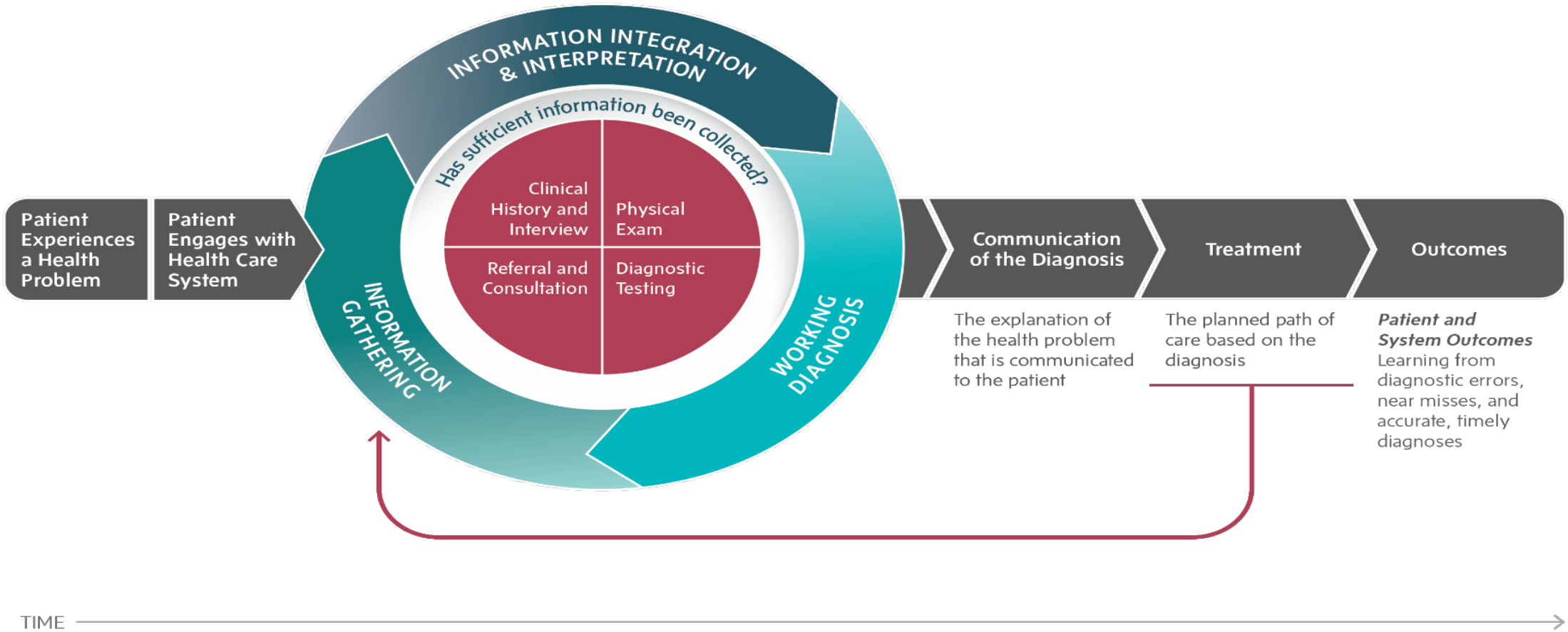
Aim 4: To determine process dysfunctions and harms from DEs.

ORIGINAL ARTICLE

An Operational Framework to Study Diagnostic Errors in Emergency Departments: Findings From A Consensus Panel

Prashant Mahajan, MD, MPH, MBA,† Cynthia Mollen, MD,‡ Elizabeth R. Alpern, MD, MSCE,§ Kelly Baird-Cox, DNP, RN, CPNP, CPEN, CEN, TCRN, NEA-BC, CENP,* Richard C. Boothman, JD,‖ James M. Chamberlain, MD,¶ Karen Cosby, MD,** Helene M. Epstein, BS,†† Jennifer Gegenheimer-Holmes, RN BSN MHSA CEN,* Michael Gerardi, MD,§§ Traber D. Giardina, PhD, MSW,‖‖ Vimla L. Patel, PhD, DSc,¶¶ Richard Ruddy, MD,*** Jason Saleem, PhD,††† Kathy N. Shaw, MD, MSCE,‡ Dean F. Sittig, PhD,‡‡‡ and Hardeep Singh, MD, MPH‖‖*

The Diagnostic Process



The National Academies of
SCIENCES · ENGINEERING · MEDICINE

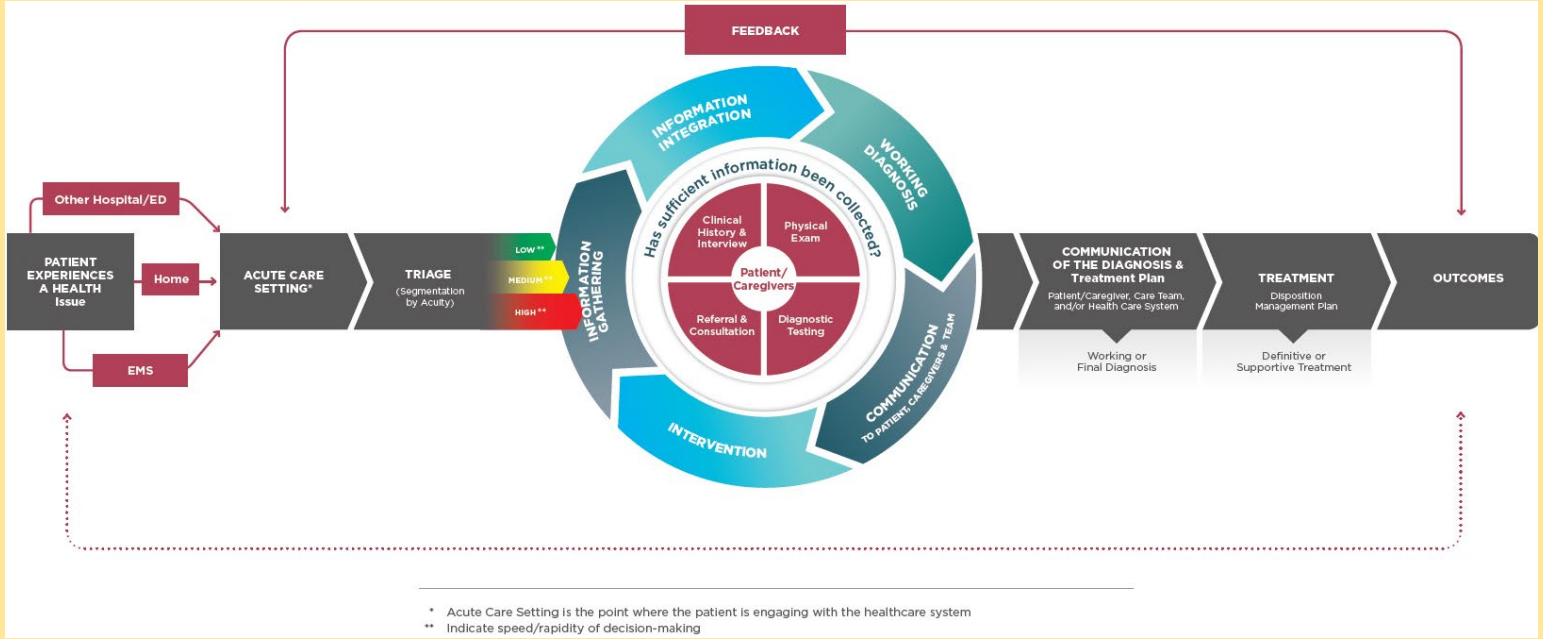
SOURCE: National Academies of Sciences, Engineering, and Medicine. 2015. *Improving Diagnosis in Health Care*. Washington, DC: The National Academies Press.

Diagnostic Process in the Emergency Department: An Adaptation of NASEM Framework

17-member expert panel consensus meeting

Modified Nominal Group Technique and Delphi process

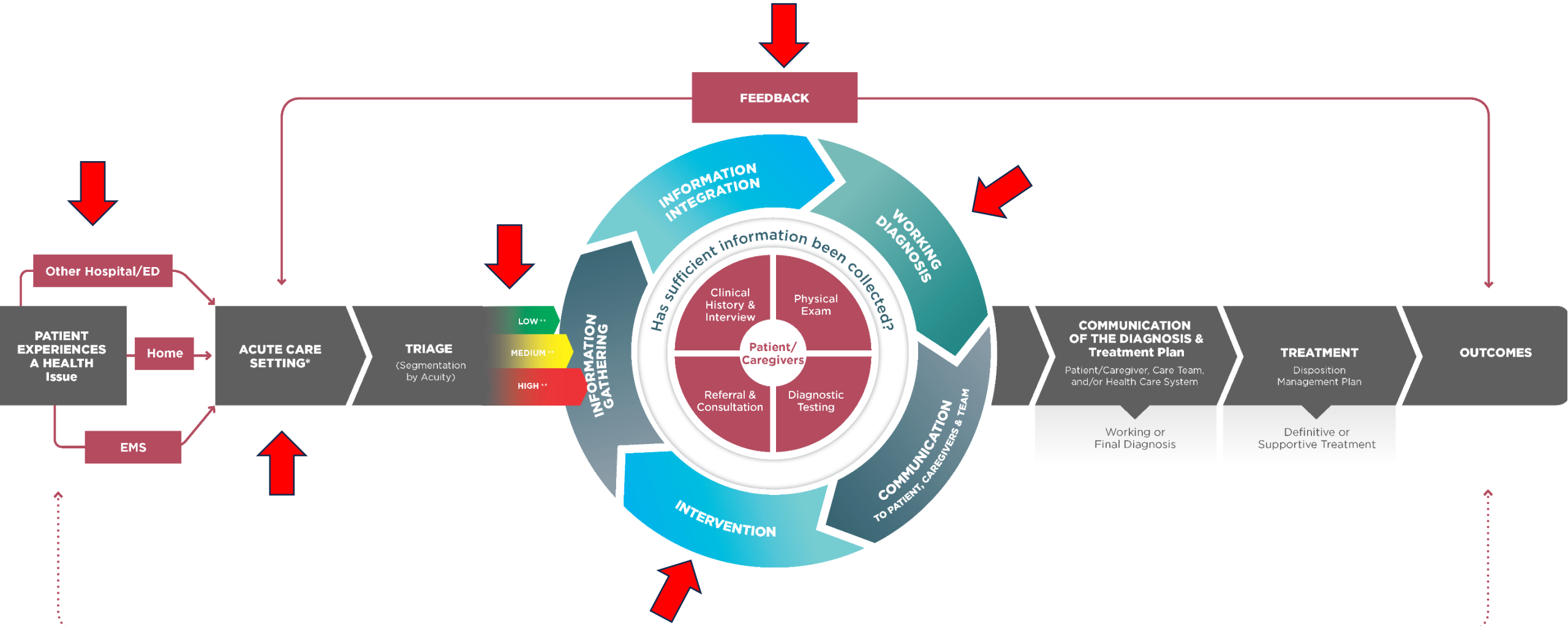
Post meeting feedback refining framework



Diagnostic errors defined as "a divergence from evidence-based processes that increases the risk of poor outcomes *despite the availability of sufficient information* to provide a timely and accurate explanation of the patient's health problem(s)."

Mahajan et al. An Operational Framework to Study Diagnostic Errors in Emergency Departments: Findings from a Consensus Panel. *J Patient Saf*. Nov 2019.

Missed Opportunities for Improving Diagnosis in Pediatric Emergency Care



R01HS024953

Aims – Pediatric EDs

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Aim 4: To determine process dysfunctions and harms from DEs.

DE GRUYTER Diagnosis 2020; aop

Prashant Mahajan*, Chih-Wen Pai, Karen S. Cosby, Cynthia J. Mollen, Kathy N. Shaw, James M. Chamberlain, Robert El-Kareh, Richard M. Ruddy, Elizabeth R. Alpern, Helene M. Epstein, Traber D. Giardina, Mark L. Graber, Laura N. Medford-Davis, Richard P. Medlin, Divvy K. Upadhyay, Sarah J. Parker and Hardeep Singh

Identifying trigger concepts to screen emergency department visits for diagnostic errors

Table 3: E-Trigger and non-EHR based signal concepts recommended by expert panel.

Data source	Trigger/Signal concepts
e-triggers	Unscheduled return to ED resulting in hospital admission Death following ED visit Care escalation following transfer to floor from ED High risk conditions based on symptom-disease dyads Return visits with new therapeutic interventions[a] Change of service during admission from the ED
Non-EHR based signals[a]	Cases discussed in morbidity and mortality conference Cases from risk management/safety office Cases referred to division chief/medical director Cases from provider feedback and patient complaints Radiology misread cases and/or laboratory call backs

Aims – Pediatric EDs

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Aim 3: Implement triggers to determine the frequency of DEs.

Aim 4: To determine process dysfunctions and harms from DEs.

Received: 30 August 2024 | Revised: 18 December 2024 | Accepted: 18 December 2024

DOI: 10.1111/acem.15087

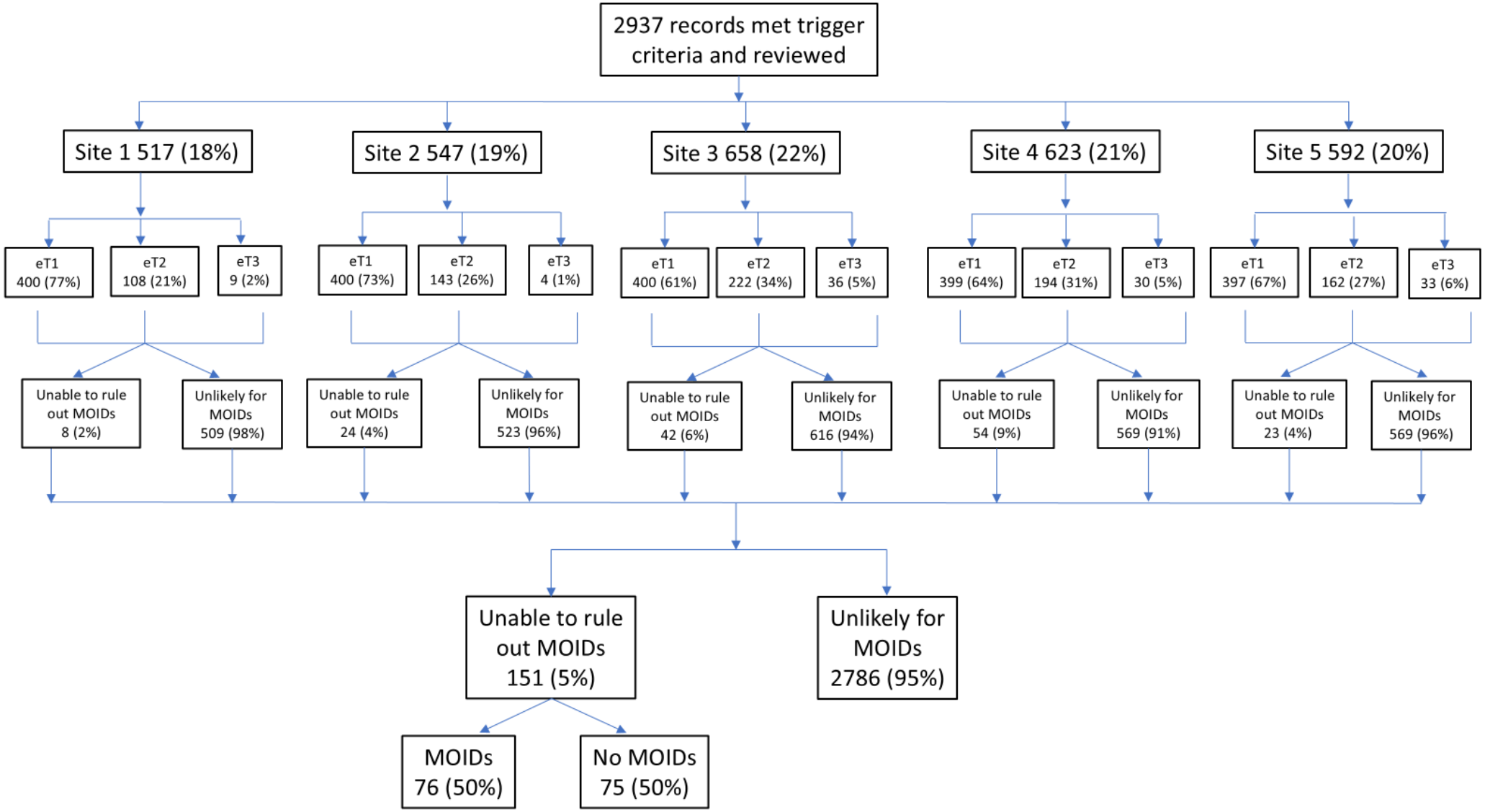
Academic Emergency Medicine

ORIGINAL ARTICLE

Epidemiology of diagnostic errors in pediatric emergency departments using electronic triggers

Prashant Mahajan MD, MPH, MBA[1] | Emily White MS[1] | Kathy Shaw MD, MSCE[2] | Sarah J. Parker MPH[1] | James Chamberlain MD[3] | Richard M. Ruddy MD[4] | Elizabeth R. Alpern MD, MSCE[5] | Jacqueline Corboy MD, MS[5] | Andrew Krack MD, MS[4] | Brandon Ku MD[2] | Daphne Morrison Ponce MD[6] | Asha S. Payne MD, MPH[3] | Elizabeth Freiheit PhD[1] | Gregor Horvath MS[1] | Giselle Kolenic MA[1] | Michele Carney MD[1] | Nicole Klekowski MD[1] | Karen J. O'Connell MD, MEd[3] | Hardeep Singh MD, MPH[7]

Apply three electronic triggers (eT) to study frequency and contributory factors of diagnostic errors in pediatric EDs:	eT1 Return visits within 10 days resulting in admission
	eT2 Care escalation to intensive care unit within 24 hours of ED presentation
	eT3 Death within 24 hours of ED visit

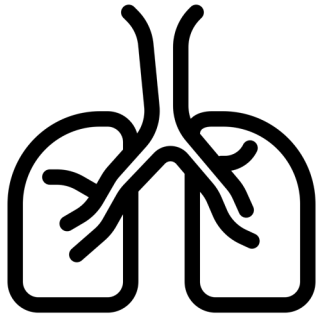


Frequency of Diagnostic Errors – **2.5%**

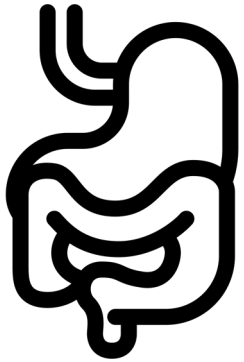
Body System	Diagnoses/Conditions
Nervous System (19) **25%**	Brain lesions/infections/bleeds (14) Infant botulism (1) Infantile seizures (2) Meningitis (2)
Gastrointestinal (17) **22.4%**	Appendicitis (8) Cholecystitis (1) Constipation (1) Diaphragmatic hernia (1) Esophagitis/gastritis (1) Intussusception (1) Pancreatitis (2) Pinworms (1) Pyloric stenosis (1)
Pulmonary (13) **17%**	Acute chest (1) Pneumonias & lung abscess (12)
Kidney (10) **13.2%**	Hemolytic uremic syndrome (1) Nephroblastoma (1) Nephrotic syndrome (1) Pyelonephritis/urinary tract infection (6) Wilms tumor (1)
Other (7) **9.2%**	Hypoglycemia (1) Infections (4) Kawasaki Disease (1) Severe iron deficiency anemia (1)
Bone (5) **6.6%**	Osteomyelitis (5)
Ear, nose and throat (5) **6.6%**	Pansinusitis with orbital cellulitis (1) Retropharyngeal abscess (1) Septal hematoma (1) Tracheitis (1) Vocal cord dysfunction (1)

Most common diagnoses associated with MOIDs

Brain lesions, infections, or hemorrhage (14/76)



Pneumonias and lung abscess (12/76)



Appendicitis (8/76)

Aims – Pediatric EDs

Aim 1: Develop a measurement framework to study DEs.

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Aim 4: To determine process dysfunctions and harms from DEs.

Patient

Provider

System

Patient-Provider

In the meantime,.....

Open access Original research

BMJ Open Quality

Types of diagnostic errors reported by paediatric emergency providers in a global paediatric emergency care research network

Prashant Mahajan ,[1] Joseph A Grubenhoff,[2] Jim Cranford,[3] Maala Bhatt,[4] James M Chamberlain,[5] Todd Chang,[6] Mark Lyttle,[7] Rianne Oostenbrink,[8] Damian Roland,[9] Richard M Ruddy,[10] Kathy N Shaw,[11] Robert Velasco Zuniga,[12] Apoorva Belle,[3] Nathan Kuppermann,[13] Hardeep Singh[14]

Improving Diagnosis in Emergency and Acute Care: A Learning Laboratory (IDEA-LL)

- Aim 1: Use systems engineering approaches to identify factors contributing to ED diagnostic error
- Aim 2: Design and develop ED-based diagnostic error prevention interventions
- Aim 3: Implement and evaluate the impact of interventions on diagnostic error risk reduction in EDs

R18HS026622

Improving Diagnosis in Emergency and Acute Care: A Learning Laboratory (IDEA-LL)

- **Aim 1: Use systems engineering approaches to identify factors contributing to ED diagnostic error**
  - 1.1 Perform prospective ED observation in situ to map the anatomy of the diagnostic process.
  - 1.2 Conduct interviews with key stakeholders including frontline ED staff and patients to identify vulnerabilities of the diagnostic process.
  - 1.3 Use data mining/machine learning to compare an at-risk, trigger-positive sample to trigger-negative charts to identify various patient, provider/care-team and systems factors that influence diagnostic safety.

R18HS026622

Open access Protocol

BMJ Open

Understanding diagnostic processes in emergency departments: a mixed methods case study protocol

Michelle Daniel ,[1] SunYoung Park,[2] Colleen M Seifert,[3] P Paul Chandanabhumma,[4] Michael D Fetters,[4] Eric Wilson,[5] Andrew B Canvasser,[3] Hardeep Singh,[6,7] Kalyan Pasupathy,[8] Prashant Mahajan[9]

Video Recording Preparation

Informational sessions for staff in both pediatric and adult EDs

Distributed study overview

Opt-out process

Pilot shadowing in both ED settings to test feasibility

Observation and Filming

Staff and patients are briefed day-of observation and can request to have recording stopped at any point

Physician wears a micro-camera and microphone to capture first-person perspective

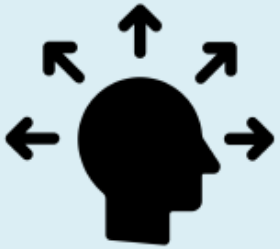
Capture 2 hours of video during clinical shift

Trained researcher takes field notes of contextual factors

Recall Interview

Physician "thinks aloud" while watching short video clips of their practice

Brings habitual, subconscious behaviors to the conscious level



Video-based ethnography is a feasible but a labor-intensive process.

This methodology is unique and can help us understand and unravel cognitive aspects of diagnosis.

We will learn how diagnostic cognition is distributed across providers, settings, and tools.

Using Video Ethnography and Stimulated Recall Interviews to Describe the Diagnostic Process in the Emergency Department

Milisa Manojlovich, PhD, RN; Caitlin Cassady, PhD; Sarah Parker, MPH; Ellie Davis; Charlotte Ahr, MSN, RN; David Ryamukuru, MSN; Anna Wang BSN; Kal Pasupathy, PhD; Hardeep Singh, MD, MPH; Prashant Mahajan, MD, MPH, MBA

METHODS

11 ED physicians from adult and pediatric ED

Physician wore micro-camera for 2 hours during clinical shift

Identified video clips related to diagnostic process.

Semi-structured interviews using video clips to stimulate recall

Inductive and deductive coding by research team

Identified themes related to cognition and diagnostic process

THEMES AND EXEMPLARS

Quality communication facilitates information flow.

"Sometimes when you are talking through your thinking process … it gives them [patients and family] time … to add more information." (Participant 7)

"As data comes back, he [PA] understands my own thinking and we're contributing to the diagnostic process equally." (Participant 10)

Cognition is complex and distributed across members of the ED team.

Artifacts can enhance the diagnostic process.

"I can look at the picture from wound clinic … and then as I'm doing my exam, I can compare what I'm seeing now." (Participant 5)

"You could be the greatest clinician and not make a mistake, but if you're only seeing 30% of patients, at what cost, right?" (Participant 1)

Efficiency is balanced against safety and accuracy.

The Joint Commission Journal on Quality and Patient Safety 2024; 50:480–491

Frontline Providers' and Patients' Perspectives on Improving Diagnostic Safety in the Emergency Department: A Qualitative Study

Courtney W. Mangus, MD; Tyler G. James, PhD; Sarah J. Parker, MPH; Elizabeth Duffy, MPH; P. Paul Chandanabhumma, PhD, MPH; Caitlin M. Cassady, LMSW, LCSW; Fernanda Bellolio, MD, MS; Kalyan S. Pasupathy, PhD; Milisa Manojlovich, PhD, RN; Hardeep Singh, MD, MPH; Prashant Mahajan, MD, MBA, MPH

Results

Interviews were conducted with:

- 10 physicians (5 general EM, 5 pediatric EM)
- 15 ED nurses
- 8 patients/caregivers

Intervention ideas were classified into themes:

- Communication
- Information gathering
- ED organization & infrastructure
- Patient education & self-management
- Electronic health record use

Select participant quotes identifying vulnerabilities in the diagnostic process and opportunities for intervention

Information gathering

"I know in the clinic, uh, the patient actually fills out the review of systems. And so the provider can look at it ahead of time, but we don't have that in the ED, which I think is a wasted tool."

Physician

Electronic health record use

"Yeah, it might as well be in Latin, you know, for a lot of things. I think, you know, they give you the standard range of that. It tells you whether you're high or low, but the explanations…"

Patient

ED organization and infrastructure

"I wonder sometimes, uh, could we be more efficient some way..it was always that nickel and diming of orders that, uh, can be hard for a nurse sometimes. So, we may wait to wait and see, are they gonna add on more orders?"

Nurse

Patient education and self-management

"But maybe if it's a new diagnosis for someone after going to the emergency department, it would be worth it to have like all the materials, but also, like for educational purposes, links to support groups or websites about the condition that you have been diagnosed with. Especially if it is something rare."

Patient

Communication

"The communication between outside hospitals, EDs, and even, uh, EMS can be sometimes super lacking…I'm like super detail oriented. So, when you ask questions on like, you know, what happened and they can't really answer it, that gets frustrating, and things get missed."

Nurse

Select opportunities for interventions to improve the diagnostic process identified by EM physicians, nurses, and patients

- **Communication**
  - Standardize communication from transferring/referring hospitals, EDs, or clinics
- **Information gathering**
  - Review of systems template for patient to complete while awaiting evaluation in ED
- **ED organization & infrastructure**
  - Pre-discharge team huddle triggered by certain patient conditions or presentations
- **Patient education & self-management**
  - Empower patient to update electronic health record items including medication list and medical history
- **Electronic health record use**
  - Include a plain language explanation of test purpose and result interpretation for test results that automatically populate to electronic health record

JAMIA Open, 2025, **8(2)**, ooaf029
https://doi.org/10.1093/jamiaopen/ooaf029
Research and Applications

Research and Applications

"Everything is electronic health record-driven": the role of the electronic health record in the emergency department diagnostic process

Tyler G. James, PhD, MCHES[1], Courtney W. Mangus, MD, MS[2,3,*], Sarah J. Parker, MPH[2], P. Paul Chandanabhumma, PhD, MPH[1], C.M. Cassady, MSW[4], Fernanda Bellolio, MD[5,6,7], Kalyan Pasupathy, PhD[8], Milisa Manojlovich, PhD, RN[9], Hardeep Singh, MD, MPH[10,11], Prashant Mahajan, MD, MPH, MBA[2,3]

Protocol

Monitoring Diagnostic Safety Risks in Emergency Departments: Protocol for a Machine Learning Study

Moein Enayati[1], PhD; Mustafa Sir[2], PhD; Xingyu Zhang[3], PhD; Sarah J Parker[4], MPH; Elizabeth Duffy[4], MA; Hardeep Singh[5], MD, MPH; Prashant Mahajan[4], MD, MPH, MBA; Kalyan S Pasupathy[1], PhD

Improving Diagnosis in Emergency and Acute Care: A Learning Laboratory (IDEA-LL)

- **Aim 2: Design and develop ED-based diagnostic error prevention interventions**
  - 2.1 Use participatory design with patients and ED clinicians to generate intervention design ideas and to identify at least one patient, one provider/care-team, and one system-focused intervention for development, i.e. a “three-pronged intervention approach”.
  - 2.2 Use human-centered design to develop an ED decision support system (ED-DSS), an EHR-based, dynamic, diagnostic error, risk prediction tool.

R18HS026622

Protocol

Identifying Interventions to Improve Diagnostic Safety in Emergency Departments: Protocol for a Participatory Design Study

Woosuk Seo[1], BSc; Sun Young Park[2], PhD; Zhan Zhang[3], PhD; Hardeep Singh[4], MD, MPH; Kalyan Pasupathy[5], PhD; Prashant Mahajan[6], MPH, MBA, MD

Original Paper

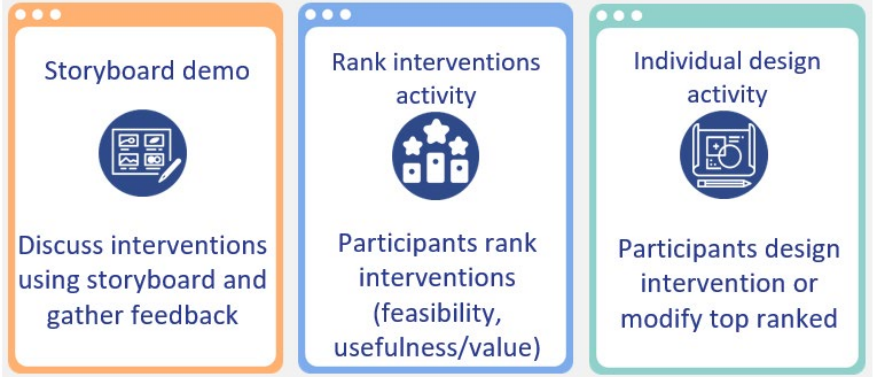
Designing Health Care Provider–Centered Emergency Department Interventions: Participatory Design Study

Woosuk Seo[1*], BS; Jiaqi Li[1*], MS; Zhan Zhang[2], PhD; Chuxuan Zheng[3], BA; Hardeep Singh[4], MD, MPH; Kalyan Pasupathy[5], PhD; Prashant Mahajan[6], MPH, MBA, MD; Sun Young Park[7], PhD

Problem Analysis Top Findings

- Extremely high cognitive load
- EHR alert fatigue
- Lack of decision support tools
- Dispersed patient history across multiple EHRs
- Missing prehospital data from EMS to ED providers during handoff
- Communication delays among care team
- Communication issues between patients and providers

User-centered Design Approach



Improving Diagnosis in Emergency and Acute Care: A Learning Laboratory (IDEA-LL)

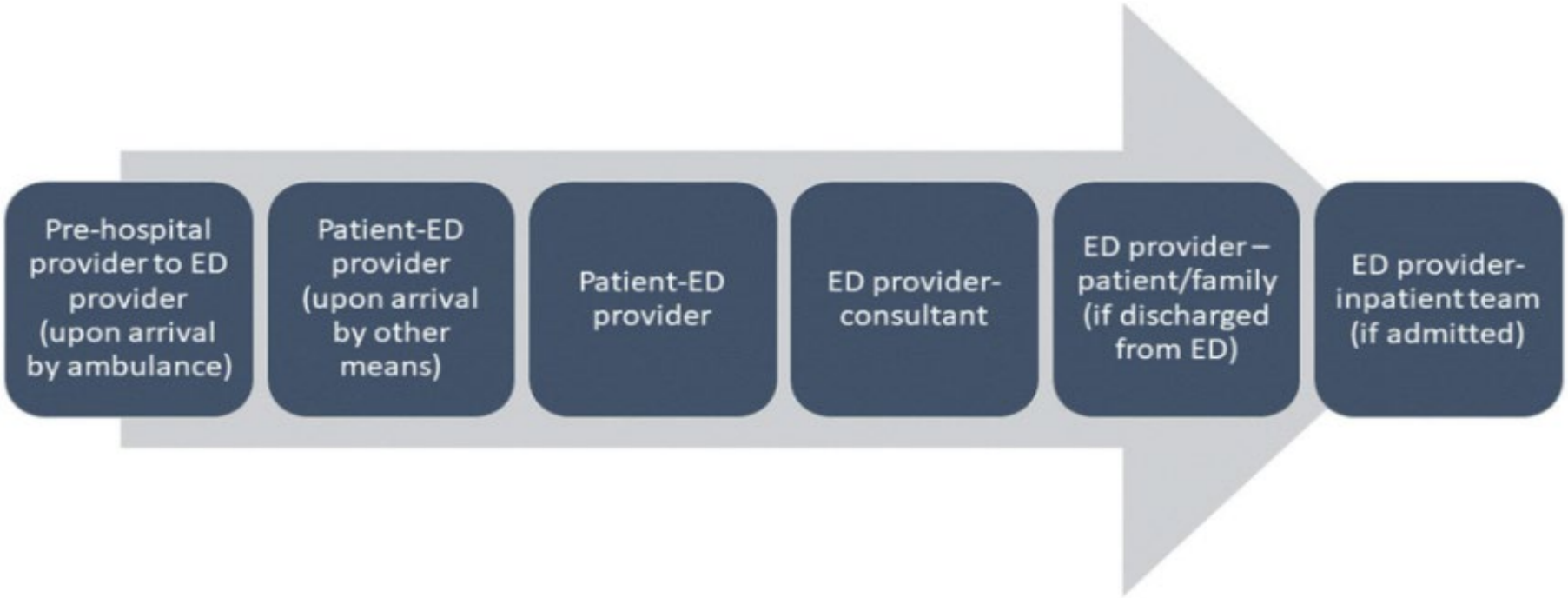
- **Aim 3: Implement and evaluate the impact of interventions on diagnostic error risk reduction in EDs**
  - 3.1 Pilot interventions in 2 academic EDs and 2 community EDs to study feasibility and demonstrate efficacy.
  - 3.2 Perform a mixed method evaluation to demonstrate the impact of interventions on risk based quantitative outcomes (e.g. reduction of diagnostic errors in trigger positive EHRs) and qualitative outcomes (e.g. improvement in diagnostic safety culture) in the two academic and two community EDs.

R18HS026622

Developing a Framework to Study and Improve Communication to Enhance Diagnostic Quality in the ED

Purpose

Reduce diagnostic errors in the ED by improving communication among patients, clinicians, and other members of the diagnostic team

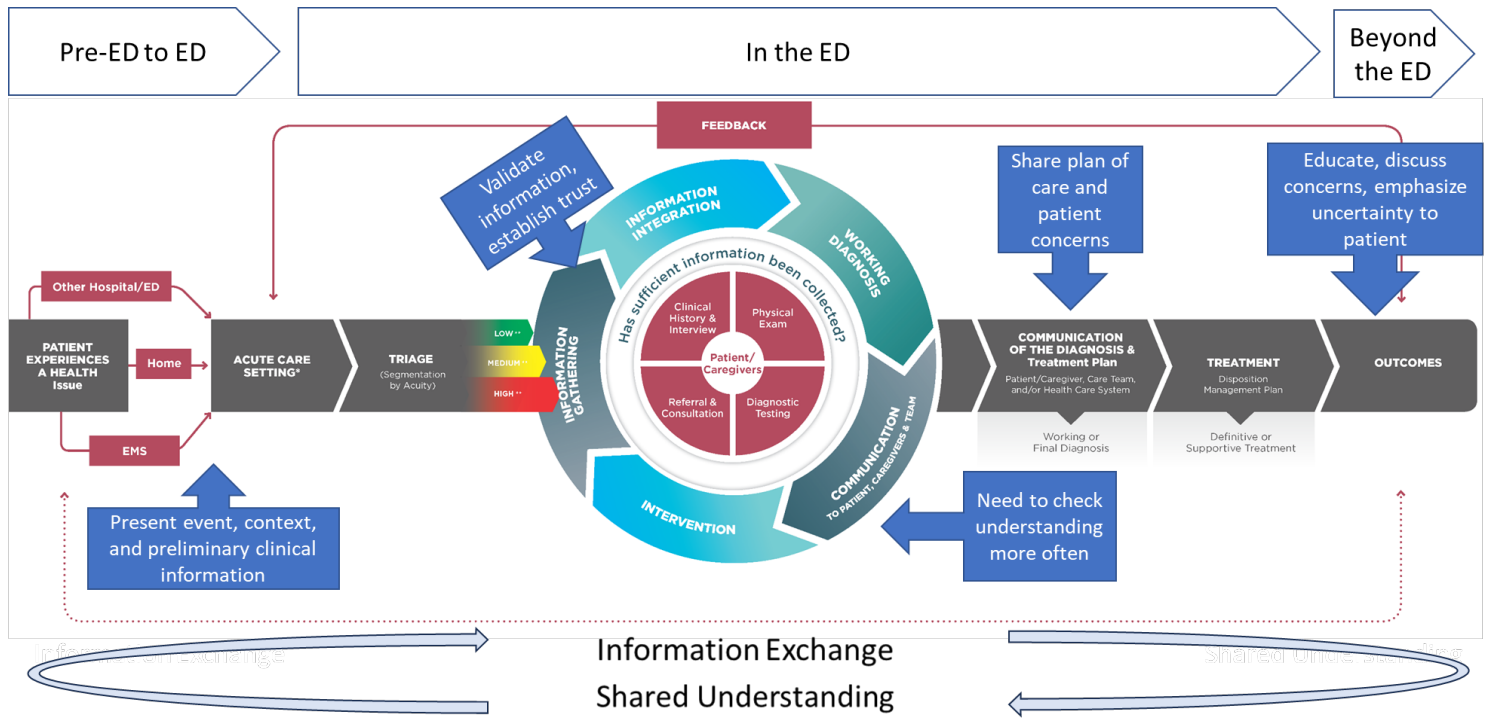


R13HS028375

The Joint Commission Journal on Quality and Patient Safety 2024; :1–9

Refining a Framework to Enhance Communication in the Emergency Department During the Diagnostic Process: An eDelphi Approach

Milisa Manojlovich, PhD, RN, FAAN; Amanda P. Bettencourt, PhD, APRN, CCRN-K, ACCNS-P; Courtney W. Mangus, MD; Sarah J. Parker, MPH; Sarah E. Skurla, MPH; Heather M. Walters, MS; Prashant Mahajan, MD, MPH, MBA



R13HS028375

RO1

R18

R13

KO8

Culture

Center for Diagnostic Excellence

Received: 17 September 2024 | Accepted: 18 September 2024

DOI: 10.1111/acem.15033

Academic Emergency Medicine

COMMENTARY

From diagnostic errors to diagnostic excellence in emergency care: Time to flip the script

Prashant Mahajan MD, MPH, MBA