Intelligent Design: Human Factors for Infection Control and Antibiotic Stewardship

Nasia Safdar, MD, PhD

February 5, 2019

William. S. Middleton Memorial Veterans Hospital and the University of Wisconsin-Madison

HERO
A Patient Safety Center of Inquiry

School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

Objectives of the Session

- Define the concept of human factors engineering
- Apply human factors engineering tools to improve infection prevention and antibiotic stewardship

Human Factors

Human factors (or **ergonomics**) is the scientific **discipline** concerned with the understanding of interactions among **humans** and other **elements** of a system, and the profession that applies theory, principles, data and methods to design in order to optimize **human** well-being and overall system performance.

Human Factors

Human Factors

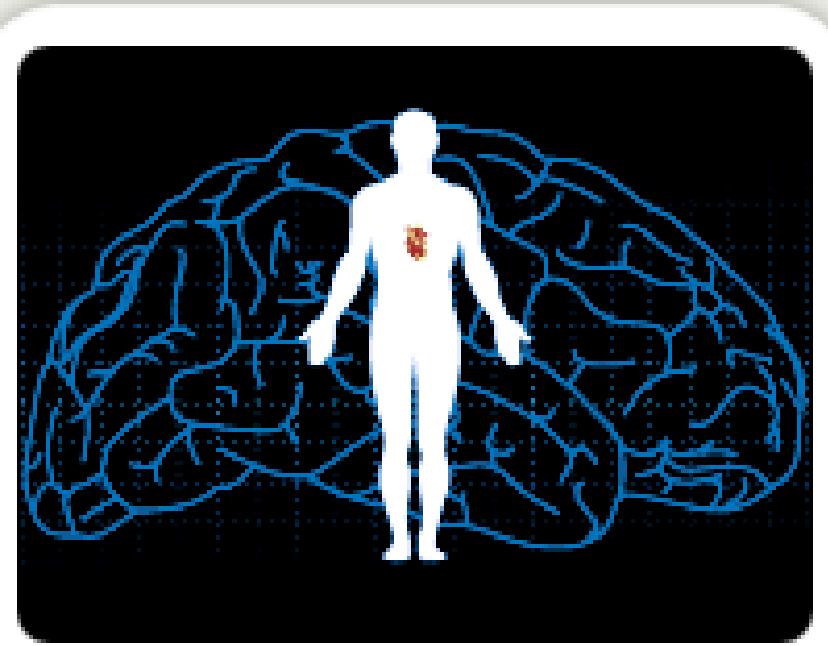
Physical Ergonomics

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. (Relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, safety and health.)

Human Factors

Cognitive Ergonomics

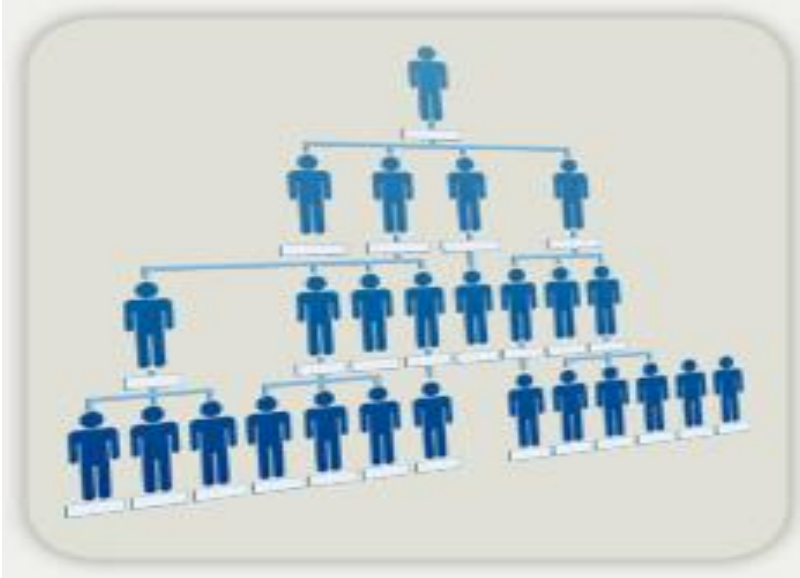
Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. (Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design.)



Human Factors

Organizational Ergonomics

Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes. (Relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, virtual organizations, telework, and quality management.)



Human Factors

- Misperceptions:
  - Fact #1: *Human factors is about designing systems that are resilient to unanticipated events*.
  - Fiction: *Human factors is about eliminating human error*.
  - Fact #2: *Human factors addresses problems by modifying the design of the system to better aid people*.
  - Fiction: *Human factors addresses problems by teaching people to modify their behaviour*.

The science of human factors: separating fact from fiction Alissa L Russ et al https://qualitysafety.bmj.com/content/22/10/802

- Fact #3: *Human factors work ranges from the individual to the organisational level*.
- Fiction: *Human factors is focused only on individuals*.

- Fact #4: *Human factors is a scientific discipline that requires years of training; most human factors professionals hold relevant graduate degrees*.
- Fiction: *Human factors consists of a limited set of principles that can be learnt during brief training*.

- Fact #5: *Human factors professionals are bound together by the common goal of improving design for human use, but represent different specialty areas and methodological skills sets*.
- Fiction: *Human factors scientists and engineers all have the same expertise*.

Human Factors/Ergonomics

HFE mechanisms	Objectives of system design
1. A work system that is not designed according to HFE design principles can create opportunities for errors and hazards (see table 2 for examples of design principles)	The objective of HFE-informed system design is to identify and remove system hazards from the design through maintenance phases.
2. Performance obstacles that exist in the work system can hinder clinicians' ability to perform their work and deliver safe care	If some obstacles cannot be removed, for instance, because they are intrinsic to the job, then strategies should be designed to mitigate the impact of performance obstacles by enhancing other system elements (ie, balance theory of job design)
3. A work system that does not support resilience can produce circumstances where system operators may not be able to detect, adapt to, and/or recover from errors, hazards, disruptions and disturbances	Work systems should be designed to enhance resilience and support adaptability and flexibility in human work, such as allowing problem or variance control at the source
4. Because system components interact to influence care processes and patient safety, HFE system design cannot focus on one element of work in isolation.**32 35**	Whenever there is a change in the work system, one needs to consider how the change will affect the entire work system, and the entire system needs to be optimised or balanced

HFE mechanisms between system design and patient safety
•HFE, human factors and ergonomics.

Human Factors/Ergonomics

Focus of HFE	Examples of HFE design principles
Physical HFE	To minimise perception time, decision time, and manipulation time
	To reduce or mitigate need for excessive physical exertion
	To optimise opportunities for physical movement
Cognitive HFE	To ensure consistency of interface design
	To match between technology and the user's mental model
	To minimise cognitive load
	To allow for error detection and recovery
	To provide feedback to users
Organisational HFE	To provide opportunities to workers to learn and develop new skills
	To allow worker control over work system
	To support worker access to social support
	To involve users in system design

Examples of HFE design principles
- **HFE, human factors and ergonomics.**

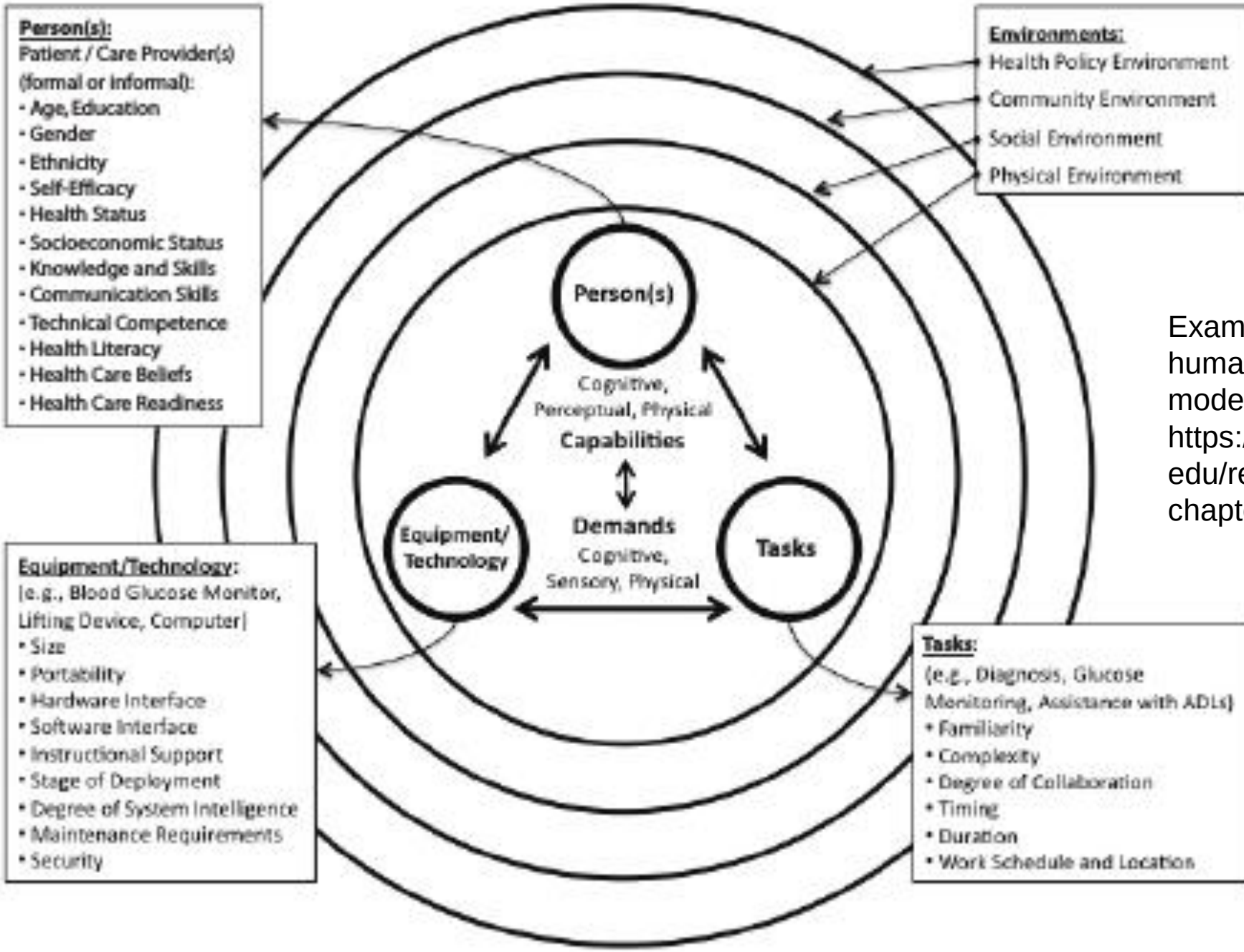
Human factors and ergonomics as a patient safety practice Pascale Carayon, Anping Xie, Sarah Kianfar
https://qualitysafety.bmj.com/content/23/3/196#block-system-main

Systems Perspective

An individual perspective may be narrow, underestimate the scope of the problem, may not be sufficient to recognize root causes and may make implementation of infection prevention for CDI challenging

A systems perspective takes the whole picture into consideration from all relevant perspectives and stakeholders

Breaks the problem down into its component parts



Example of human factors model https://www.nap.edu/read/13149/chapter/5#62

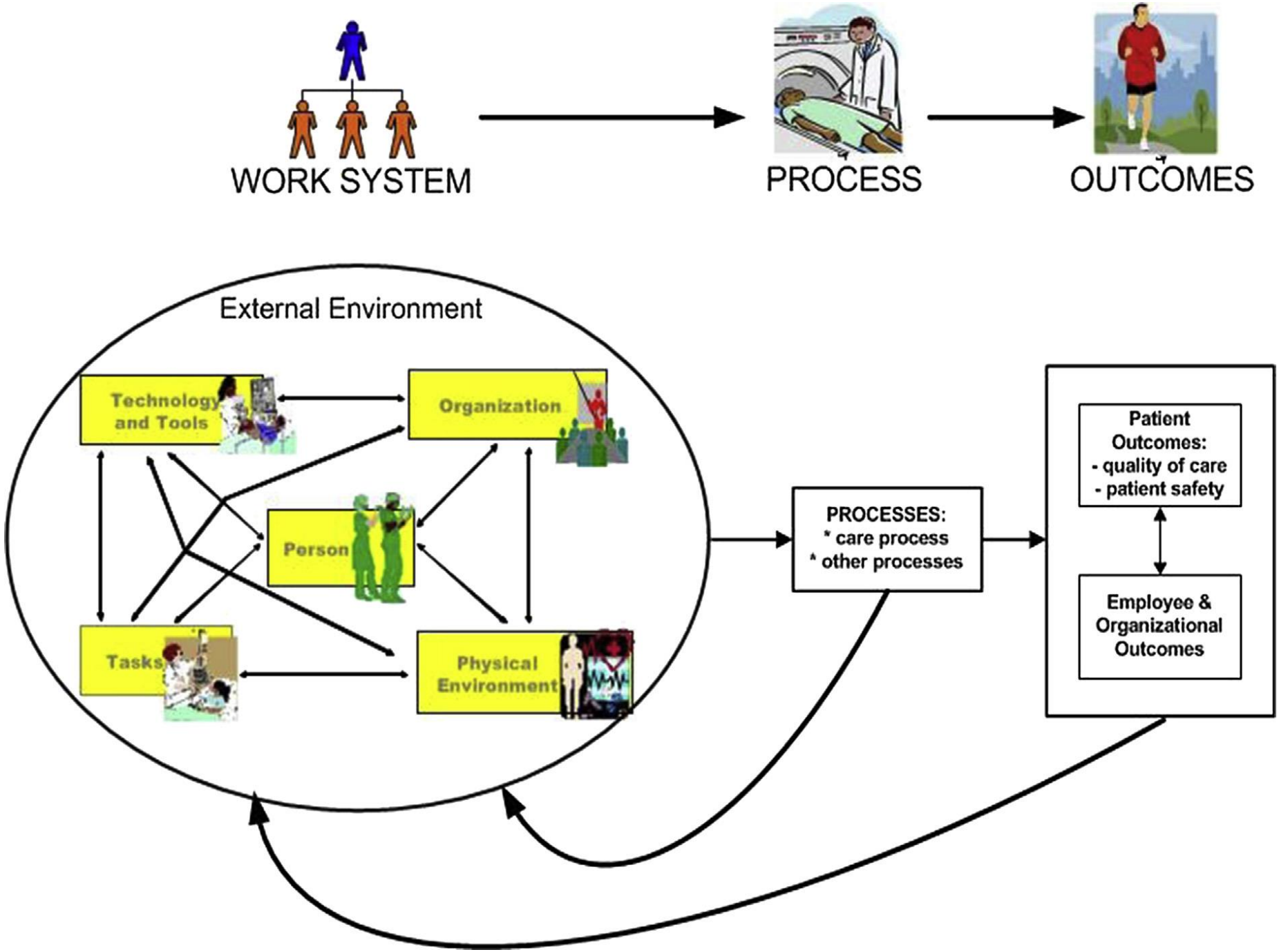
Systems Engineering Initiative for Patient Safety (SEIPS)

- One (among many) human factors model
- Widely used in healthcare

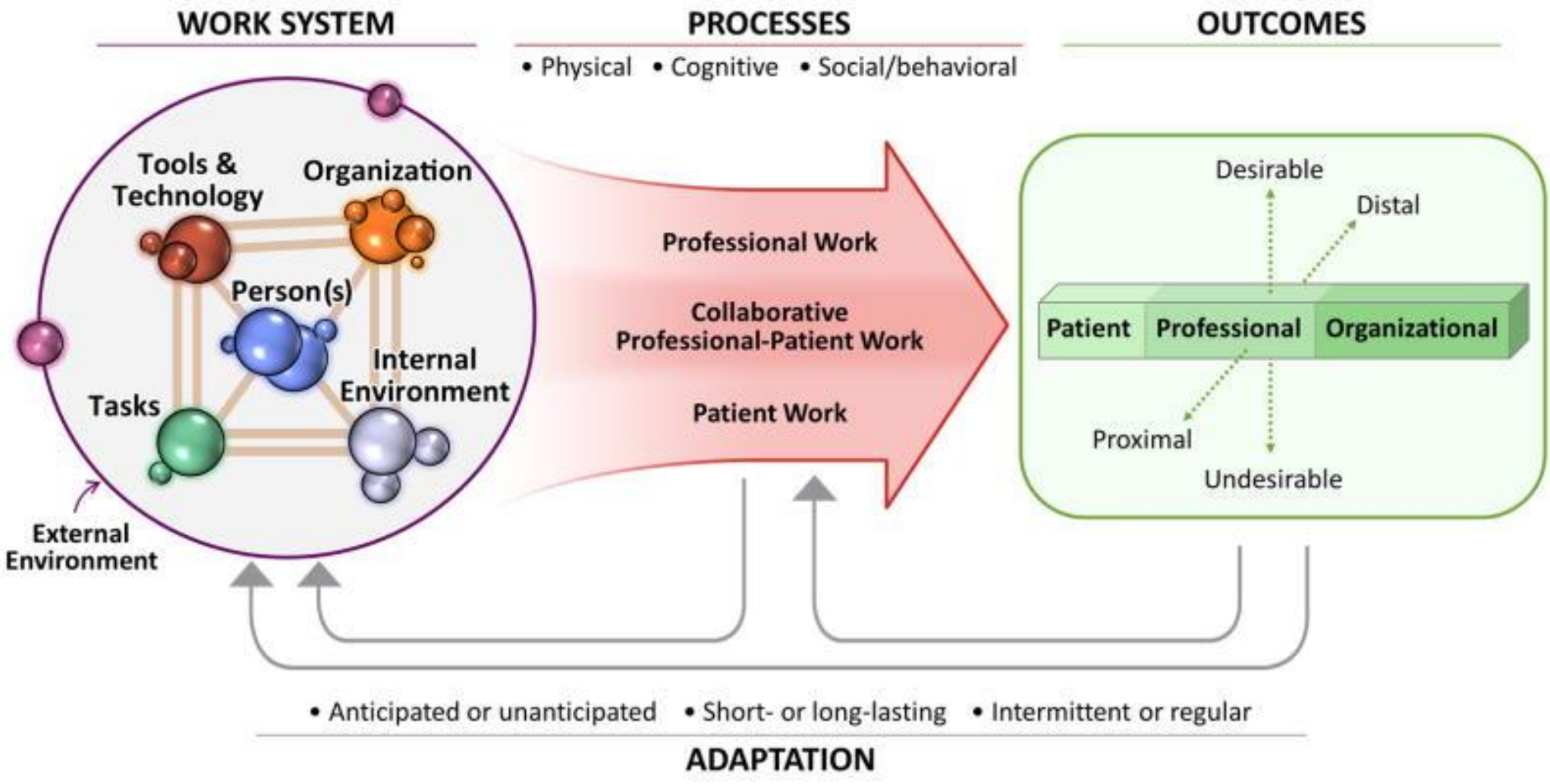
https://cqpi.wisc.edu/research/health-care-and-patient-safety-seips/

Table 2
Value of SEIPS model to healthcare.

Characteristics of SEIPS model	Value to healthcare
Integration of SPO model in SEIPS model	Healthcare professionals' familiarity with SPO model translating to adopting SEIPS model
Work system model	Broad focus, not just individual focus; support to develop wide set of solutions for redesigning system
Patient outcomes and employee/organizational outcomes	Benefits for both patients and healthcare workers
Generic model	Applicability to any healthcare domain and healthcare quality or patient safety problem
Person at the center of work system can be healthcare professional, patient, or team	Flexibility in applying model to various work systems and various people
Feedback loops from processes and outcomes, to work system	Emphasis on the need for healthcare organizations to monitor, consider, and take advantage of ongoing feedback
Process influenced by work system	Expanded view of process that integrates all work system elements Importance of care processes as well as connected processes (e.g., housekeeping)
System interactions	Emphasis on systemic impact of organizational and sociotechnical changes


WORK SYSTEM
PROCESS
OUTCOMES
External Environment
Technology and Tools
Organization
Person
Tasks
Physical Environment
PROCESSES:
* care process
* other processes
Patient Outcomes:
- quality of care
- patient safety
Employee & Organizational Outcomes

SEIPS 2.0



https://www.ncbi.nlm.nih.gov/pubmed/24088063

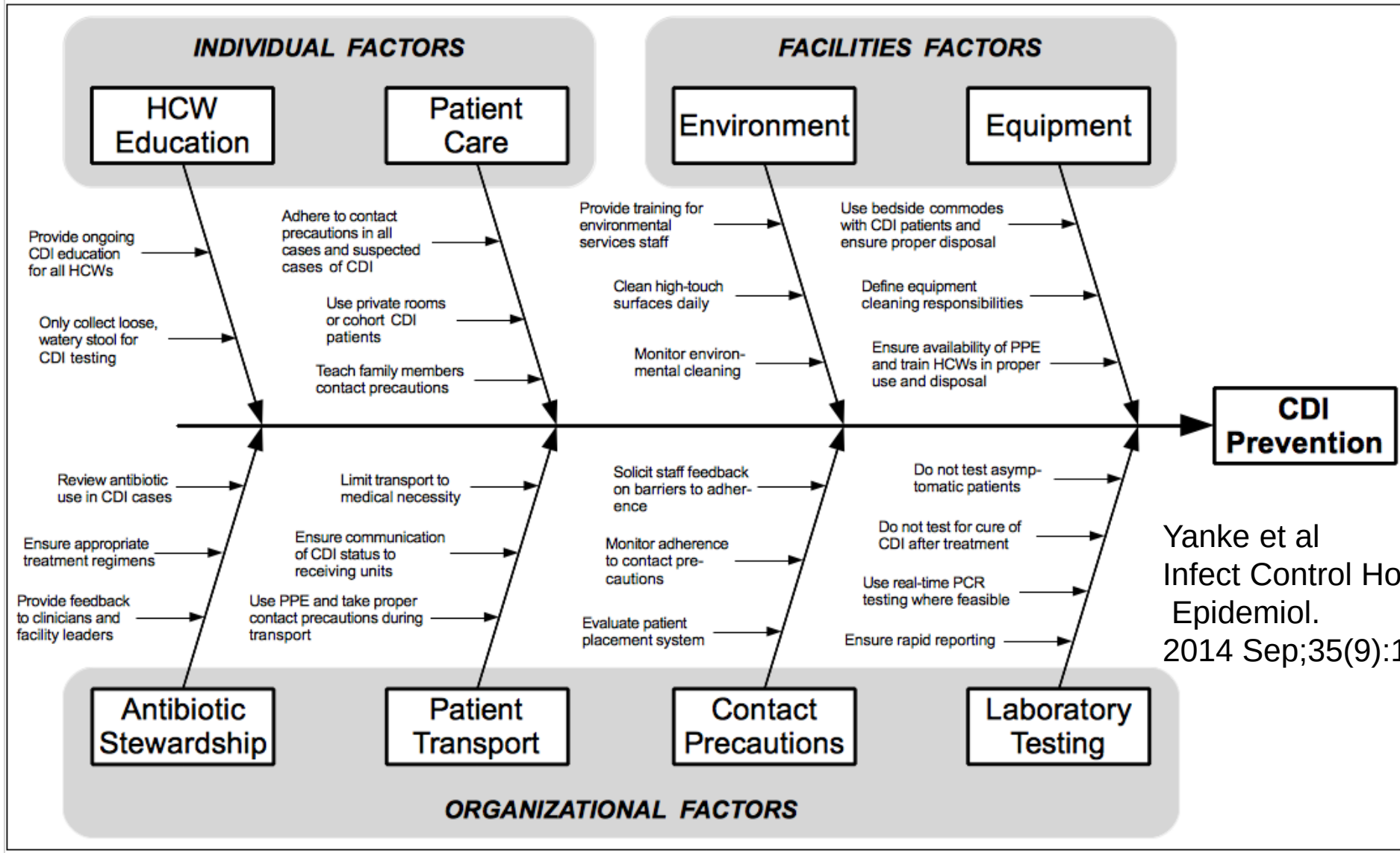
Application of SEIPS to *C. difficile* infection

Complexity of *C. difficile* infection

Challenges to containment

- Uncertain incubation period
- Multiple reservoirs
- Environmental persistence
- High rates of recurrence
- Need for soap and water for hand hygiene
- Multidisciplinary approach to containment
- Need for both infection prevention protocols and antibiotic stewardship interventions

Fishbone diagram showing the complexity of CDI



Yanke et al
Infect Control Hosp Epidemiol.
2014 Sep;35(9):1176-81

Key interventions for CDI prevention- a CDI bundle

1) rapid, appropriate diagnostic testing for *C. difficile*

2) empiric isolation for patients with diarrhea and suspected CDI

3) contact isolation for patients with confirmed CDI

4) environmental decontamination of CDI patient rooms

5) full compliance with hand hygiene by all entering and leaving CDI patient rooms.

SEIPS model for CDI

Five Components

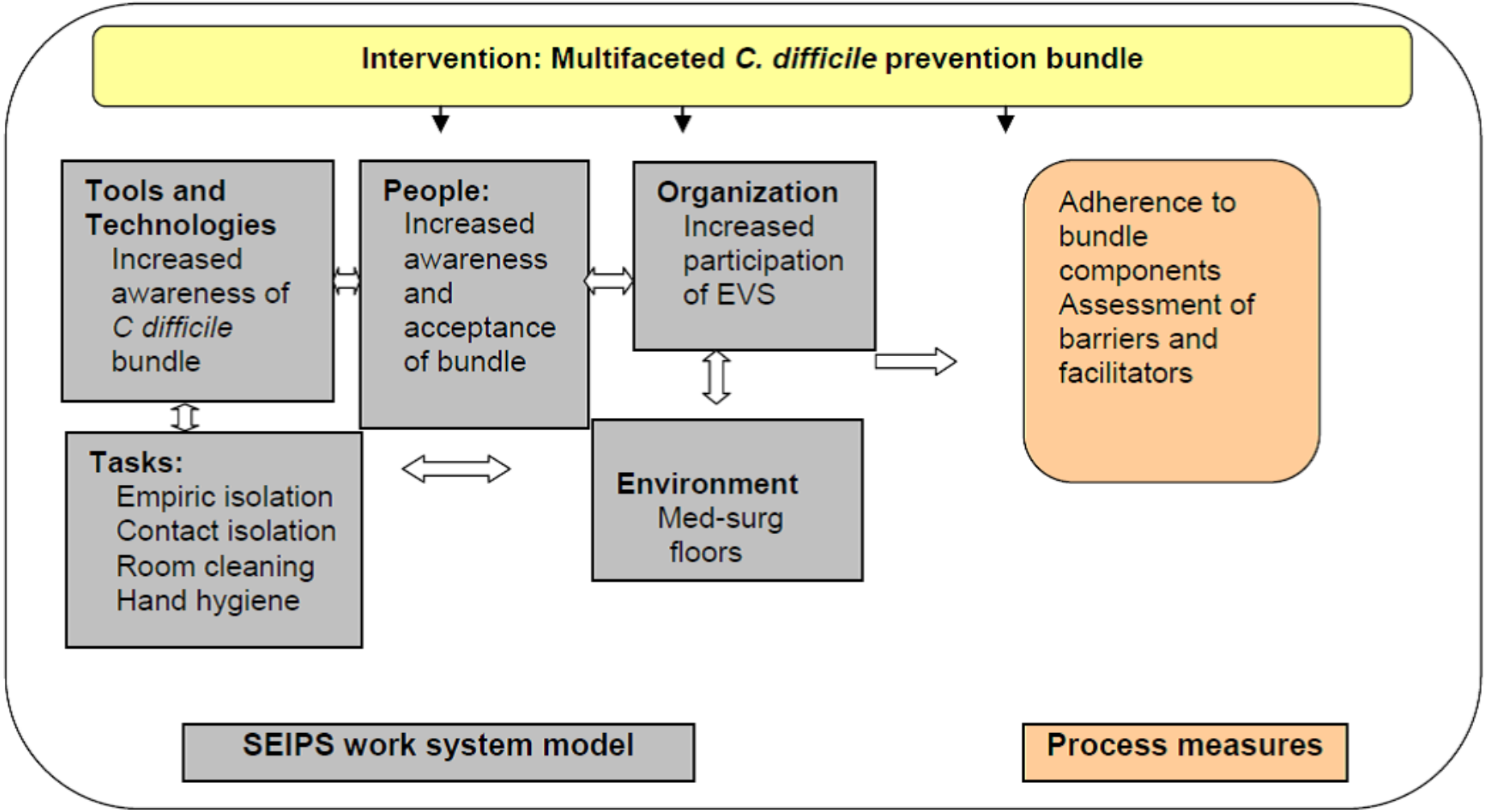
- Tools
- Technologies
- Environment
- People
- Organization
- Tasks

Barriers and facilitators to Clostridium difficile infection prevention: A nursing perspective.

Ngam C, Schoofs Hundt A, Haun N, Carayon P, Stevens L, **Safdar** N.

Am J Infect Control. 2017 Dec 1;45(12):1363-1368. doi: 10.1016/j.ajic.2017.

SEIPS for evaluation of C difficile bundle



SEIPS application to CDI

- Create a process map to understand current practice and procedures
- Review of policies and procedures, signage, diagnostic testing procedure
- Supplement this data with focus groups/interviews of relevant groups
- Supplement with direct observations of PPE donning and doffing, room layout, PPE supplies.

Data collection

- Three homogenous focus groups convened – one each comprised of physicians, nurses and environmental services workers (EVS) – over a 4-week period.
- The physician focus group included 7 medicine residents and one attending physician
- The nursing focus group included 10 nurses from medical units with varying experience
- The EVS group included six participants with 2-30 years of experience from varying types of units (ICU, medical, surgical).

- Facilitated by a human factors engineer with significant experience in healthcare group facilitation.

- Participants received no financial remuneration for attending.

- Discussion was audio recorded for transcription by a professional service and subsequently coded by two researchers

Transcripts of the three focus groups were uploaded to Dedoose® web-based qualitative data analysis software.

Each excerpt was coded to three dimensions –

1) which of the five CDI bundle interventions the excerpt corresponded to
2) which of the five elements of the work system it related to
3) and 3) whether it was a work system barrier or facilitator.

An excerpt could be coded to multiple bundle interventions, multiple work system elements and be both a barrier and facilitator.

Person.

Nurses presented an issue associated with relying on others to inform them that a patient they care for has CDI. This becomes a problem when the expectation is not met. For example, CDI patient rooms must have a sign on the door informing the person entering the room to take additional precautions.

If the person responsible for posting the sign forgets or does not post the notice, hand hygiene and other CDI interventions may not appropriately occur.

[Nurse focus group: "Or if somebody forgets to put the sign up and it's your patient … you have no idea they were in isolation.

That's (not) always great."

Tools/technology.

All three groups noted sink interference posed by the excessive amount of equipment (and also people) in the patient room.

Pose sink access issues. [EVS focus group: "(There are) huge chairs and the patient sits in front of the sink. And then we can't get to the sink to wash our hands. …
Supplies in front of the sink … (cause) interference."]

EVS staff commented on their positive and consistent use of pagers as a means of informing them that they will be cleaning a CDI patient room.

Organization.

The challenge of educating patients' families regarding their need to comply with the CDI interventions was solely discussed by nurses who noted that changes in hand hygiene practice varied based on family member perceptions.

Physicians admitted the lack of clarity of the hand hygiene policy related to when, where, and how long hand washing should occur.

Other organization issues that were identified frequently related to role-specific policies solely relevant to a particular group. For example, EVS workers discussed significant issues related to training and staff turnover that had an impact on compliance with and understanding of the importance of hand hygiene.

Institutional pressure to turnover room fast

Environment

Eight of the 52 total comments were related to sinks and were made by all three groups.

Consistent issues related to the number and location of the sinks.

[Nurse focus group: “We have to use the sinks in the hallway to wash our hands because you can’t get out of a C. diff room without recontaminating your hands after you’ve washed.”]

Tasks

Wet hands make gloving difficult

PPE when not anticipating touching patient or environment

Inconsistency in where used gowns are disposed

Inconsistency in where clean gowns are stored

Supply

SEIPS Application to PPE

Person
- Type of healthcare worker
- Patient/visitor
- Knowledge/awareness
- Perception of risk given anticipated activity

Tools/technology
- PPE cumbersome
- Use of phone/iPAD in isolation rooms difficult

Tasks
- Bundling of cares
- Increases time
- Cleaning issues

SEIPS Application to PPE

Environment
- Disposal
- Supplies
- Signage on door
- Stethoscope issues

Organization
- Policies
- Practice variation
- Leadership involvement

Facilitators
- Leadership engagement
- Consistency of messages
- Ease of availability and disposal

SEIPS and interventions

- Create a list of barriers and select ones that are modifiable and have high impact
- Examples
  - Creation of new sinks
  - Consistency of messaging- pros and cons
  - Leadership support for EVS

SEIPS and Injection Safety

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY JULY 2018, VOL. 39, NO. 7

ORIGINAL ARTICLE

Barriers and Facilitators to Injection Safety in Ambulatory Care Settings

Claire Leback, RN, BSN;[1] Diep Hoang Johnson, BS;[2] Laura Anderson, RN, BSN, MPH;[2] Kelli Rogers, MPH;[2] Daniel Shirley, MD, MS;[3] Nasia Safdar, MD, PhD[3,4]

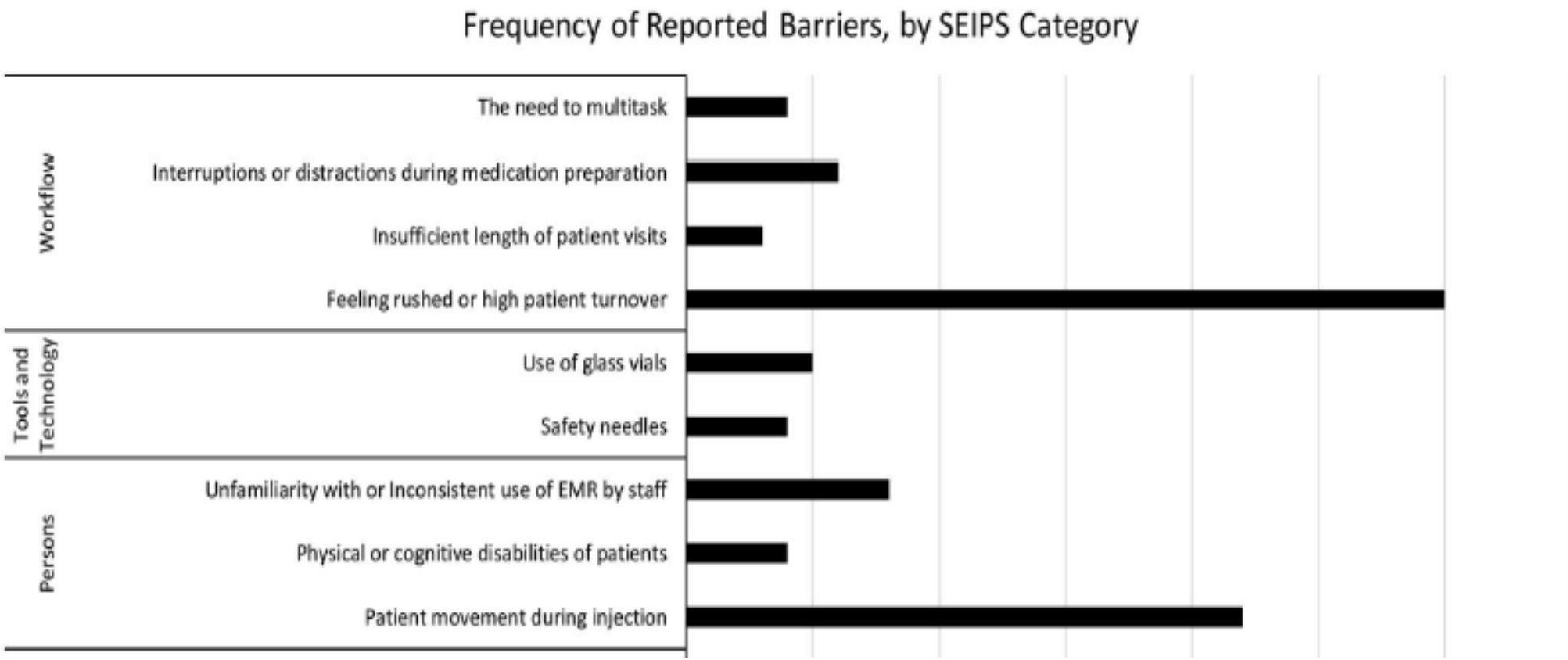
SEIPS and Injection Safety

TABLE 2. Injection Safety Interview Questions

SEIPS Element	Questions Proposed
Workflow	• Can you describe your usual workflow for giving injections? • Are there any elements in this workflow that make giving safe injections harder? • Are there any elements in this workflow that make giving safe injections easier?
Persons	• Can you think of a time when an individual (whether a staff member or a patient) has made it easier for you to give injections safely? • Can you think of a time when an individual (whether a staff member or a patient) has made it harder for you to give injections safely?
Organization	• Can you think of a time in which the organization (the clinic or the entire organization) has made it easier for you give injections safely? • Can you think of a time in which the organization (the clinic or the entire organization) has made it harder for you give injections safely?
Environment	• Can you think of and describe factors in your work environment that make it easier to give injections safely? • Can you think of and describe factors in your work environment that make it harder to give injections safely?
Tools and technology	• How has technology helped your ability to give safe injections? • How has technology hurt your ability to give safe injections?

NOTE. SEIPS, System Engineering Initiative for Patient Safety.

Barriers


Frequency of Reported Barriers, by SEIPS Category
Workflow
The need to multitask
Interruptions or distractions during medication preparation
Insufficient length of patient visits
Feeling rushed or high patient turnover
Tools and Technology
Use of glass vials
Safety needles
Persons
Unfamiliarity with or Inconsistent use of EMR by staff
Physical or cognitive disabilities of patients
Patient movement during injection

Barriers

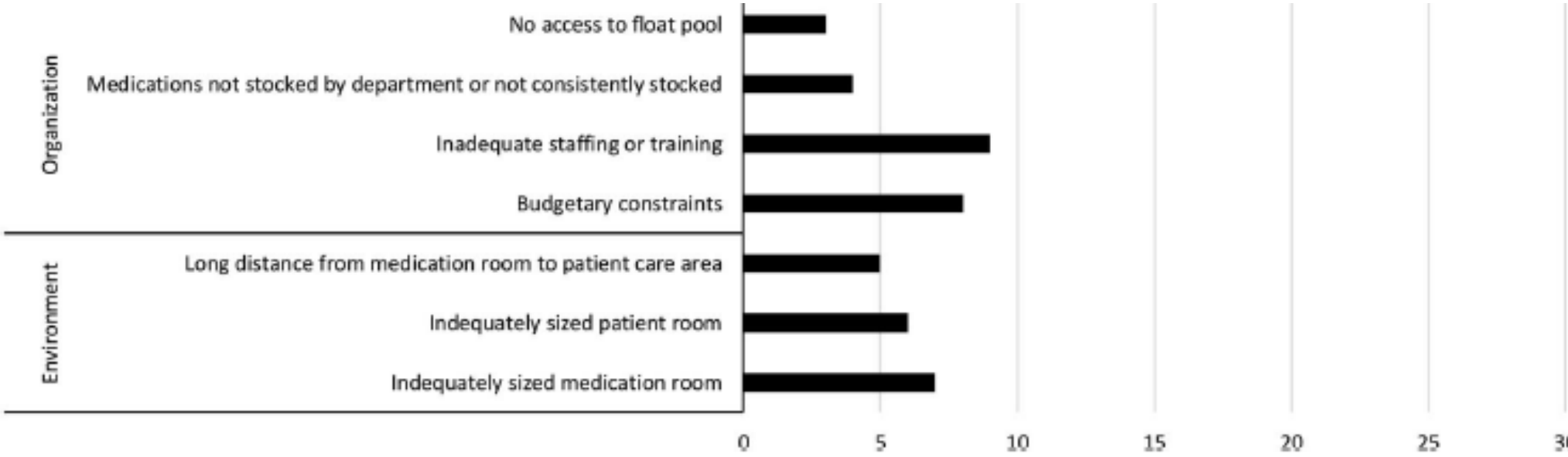
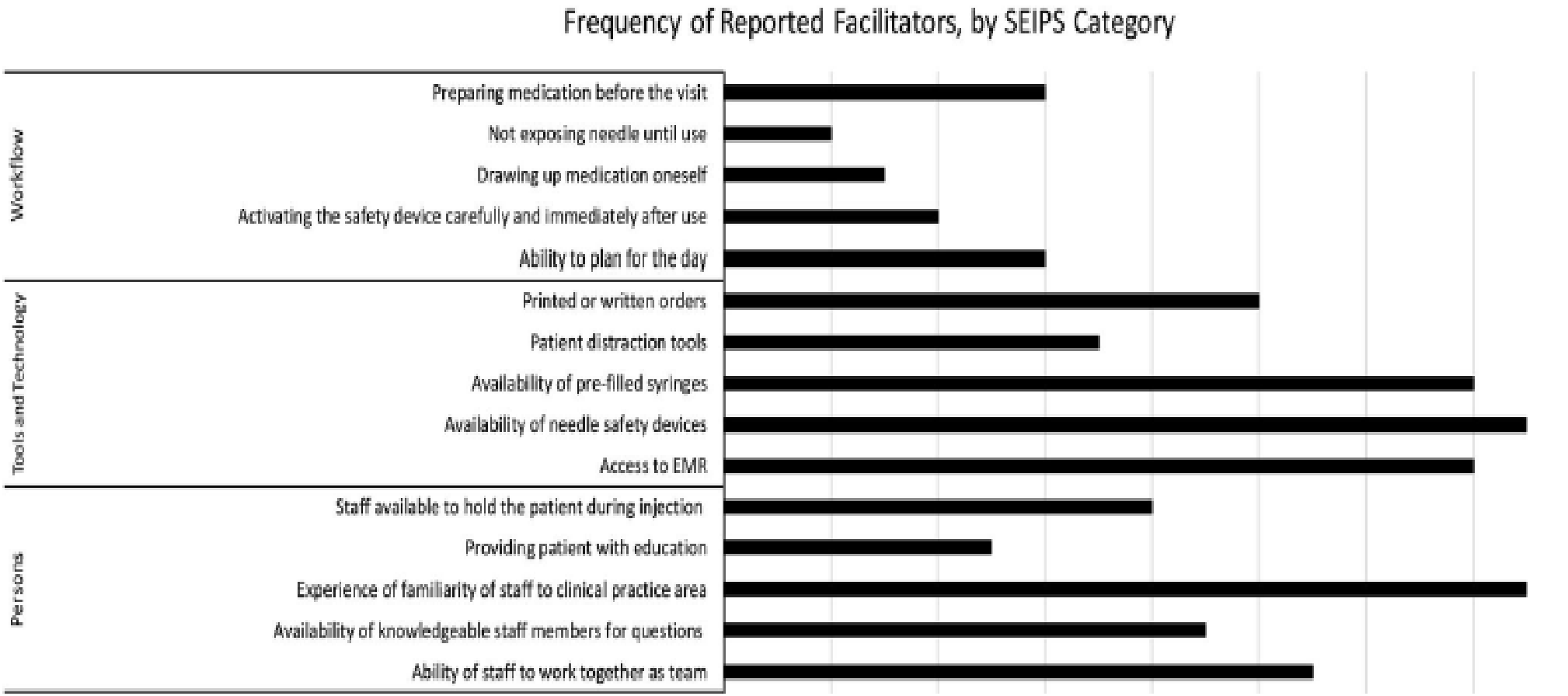
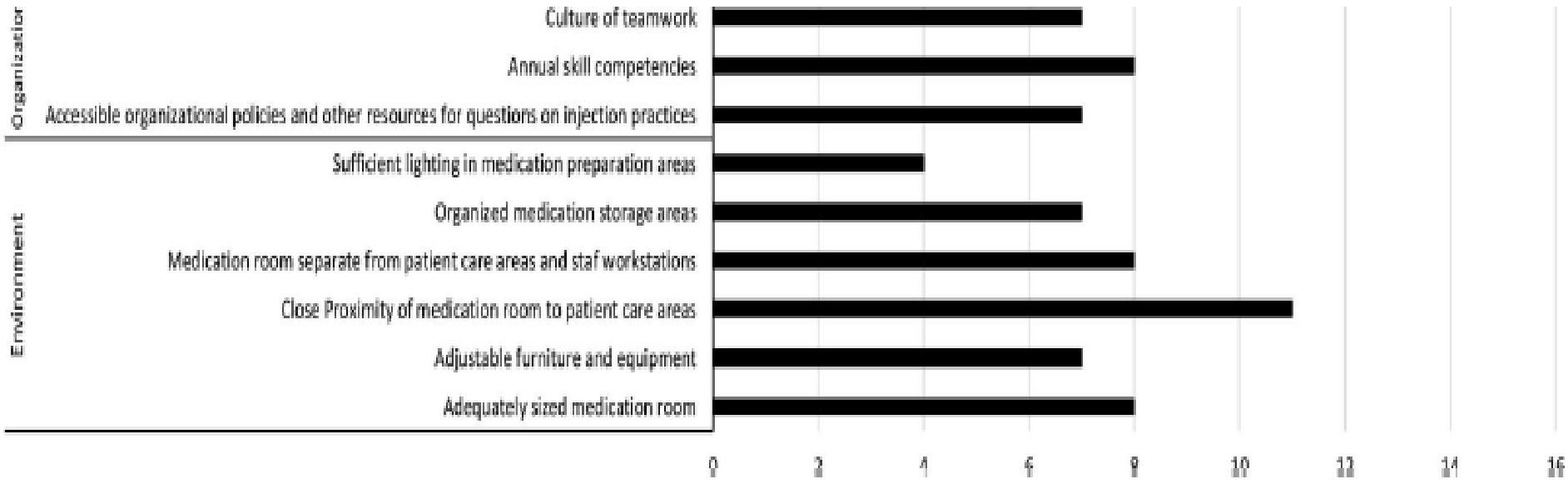


FIGURE 1. Frequency (%) of reported barriers, arranged by System Engineering Initiative for Patient Safety (SEIPS) category.

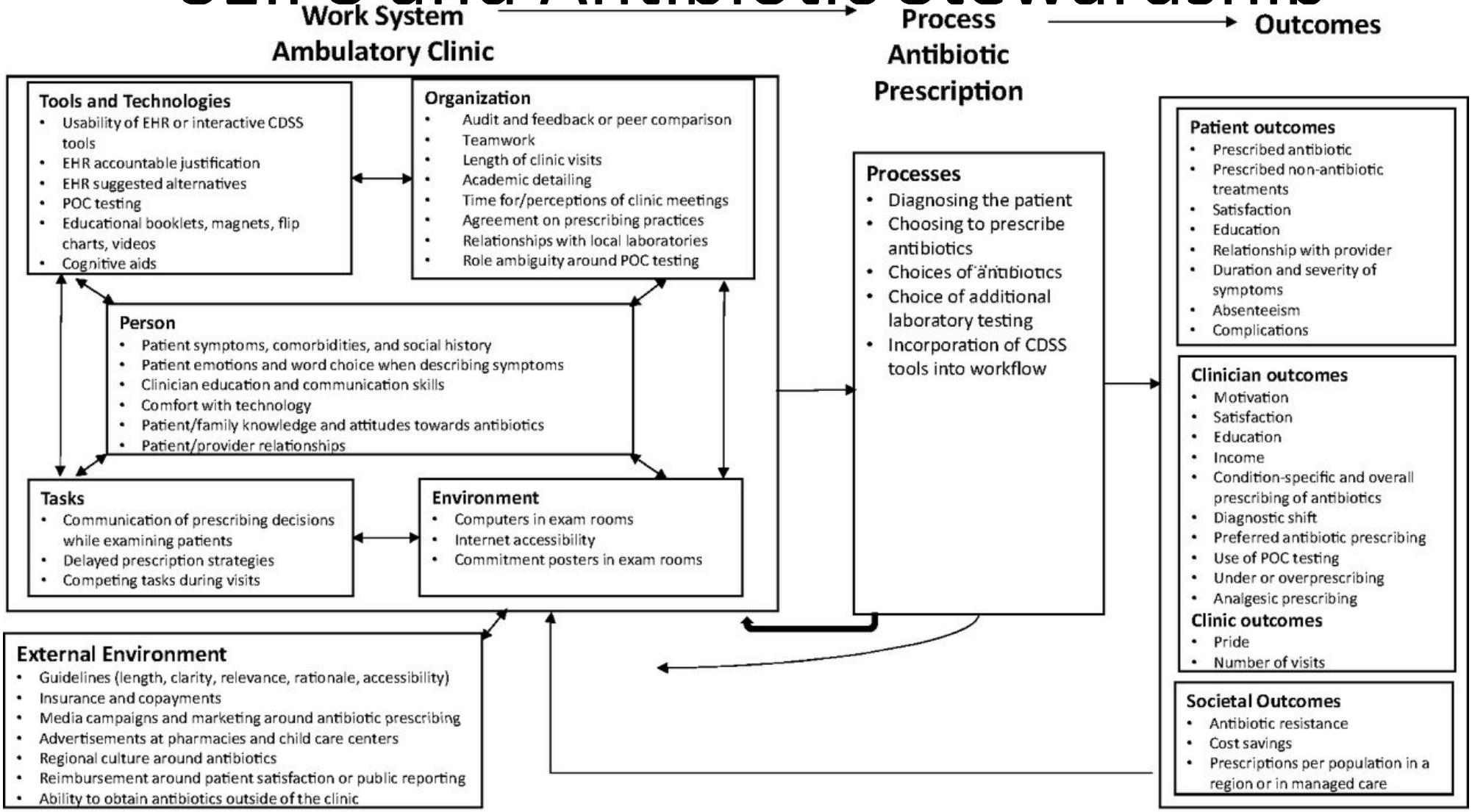
Facilitators



Facilitators



SEIPS and Antibiotic Stewardship



Abbreviations: EHR: electronic health record; CDSS: clinical decision support system; POC: point of care.

https://www.jabfm.org/content/31/3/417

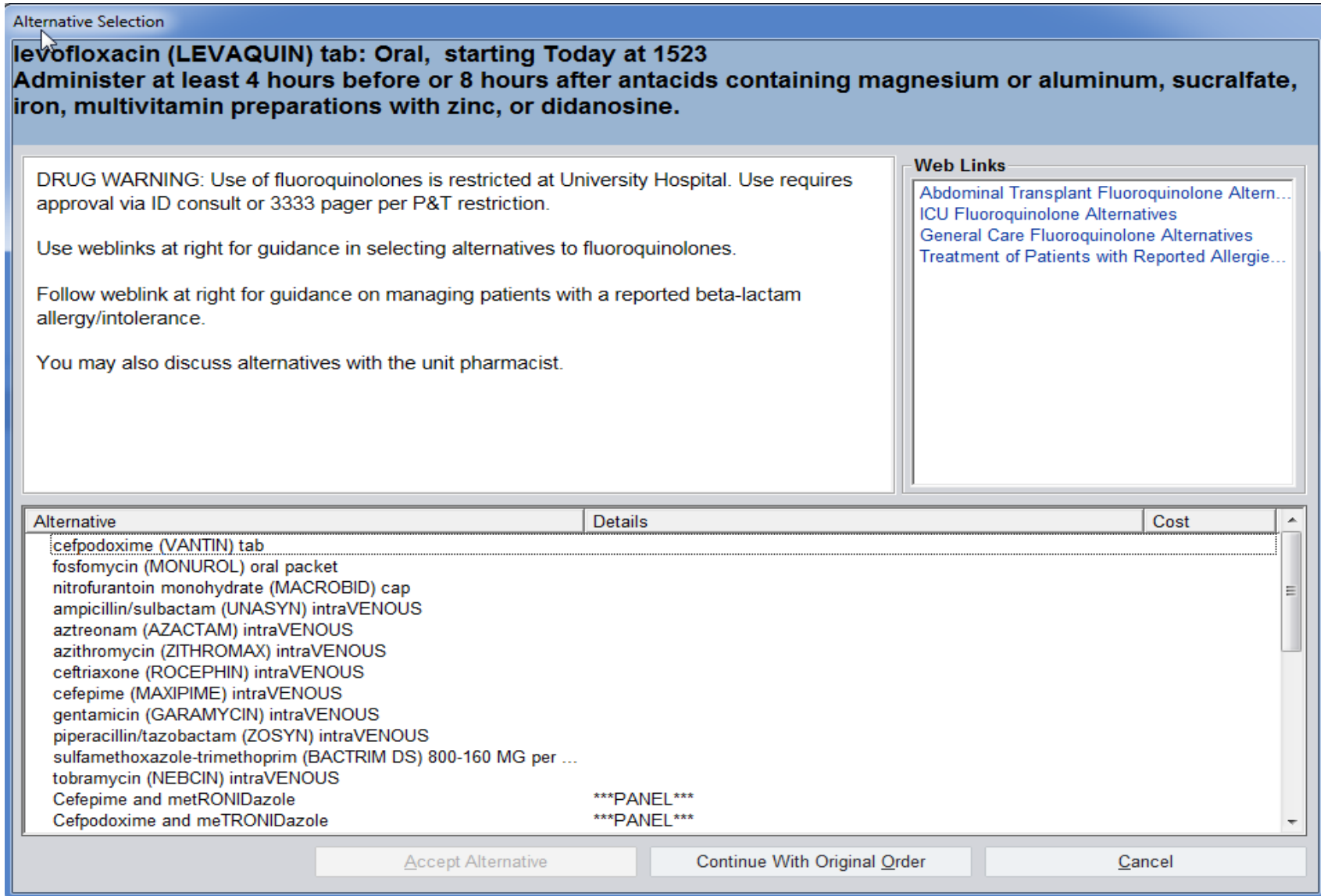
Fluoroquinolone Restriction for the Prevention of C. diff – "The FIRST Trial"

- 5-year AHRQ R01 – 8/1/18 – 7/31/23
- Cluster, randomized with 12 medical-surgical ICUs
- 12 month intervention period
- Specific Aims:
  1. Determine the impact of FQ PPA on hospital-onset and healthcare-associated CDI rates and other clinical outcomes compared with usual care using a stepped-wedge cluster RCT in ICUs.
  2. Evaluate the implementation of FQ PPA using a systems engineering approach.

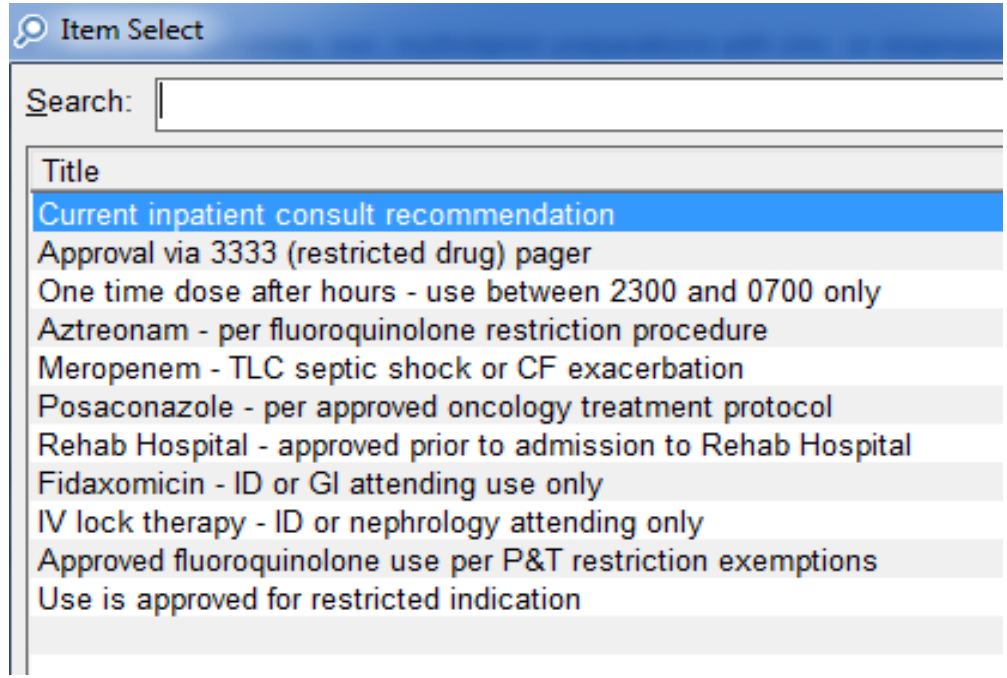
Overview of FQ PPA intervention

- When providers attempt to order FQ, an alert in EHR will appear letting them know that use of FQ is restricted. Alert will include:
  - Links to resources on possible alternative antibiotics
  - Instructions to call unit pharmacist to discuss alternatives, if necessary
  - An ordering list of alternative antibiotics (for their convenience)
- If after speaking to unit pharmacist provider still feels FQ is most appropriate, will need to contact ID attending from the antibiotic stewardship team to obtain approval
  - Will need to indicate in EHR reason for ordering FQ in dropdown

FQ Alternative Alert Screen in EPIC



FQ Medication Approval Screen



Data on Implementation Process (Qualitative)

- Documents and notes related to implementation
  - Training materials
  - Meeting minutes
- Focus group and/or interviews with attendings, residents, advanced practice providers and pharmacists
- Brief online clinician survey on intervention acceptability

Summary

- Human factors is meant to optimize human performance by improving systems
- Broad application to infection prevention and antibiotic stewardship
- Next steps are to determine if interventions designed with human factors principles are feasible, and effective in healthcare systems for preventing infections and improving antibiotic use

Acknowledgments

Funding:
AHRQ
VA
PCORI
NIH
CDC
UW-Madison