Let's Talk Informatics

Designing Health Technology Safety

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February 25, 2021.

Bethune Ballroom, Halifax, Nova Scotia

Please be advised that we are currently in a controlled vendor environment for the One Person One Record project.

Please refrain from questions or discussion related to the One Person One Record project.

Informatics…

utilizes health information and health care technology to enable patients to receive best treatment and best outcome possible.

Clinical Informatics…

is the application of informatics and information technology to deliver health care. AMIA. (2017, January 13). Retrieved from https://www.amia.org/applications-infomatics/clinical-informatics

Objectives

At the conclusion of this activity, participants will be able to…

- Identify what knowledge and skills health care providers will need to use information now and in the future.
- Prepare health care providers by introducing them to concepts and local experiences in Informatics.
- Acquire knowledge to remain current with new trends, terminology , studies, data and breaking news.
- Cooperate with a network of colleagues establishing connections and leaders that will provide assistance and advice for business issues, as well as for best-practice and knowledge sharing.

Session Specific Objectives

1. Define the current state of the research involving technology safety.
2. Define the models that have been used to conceptualize technology safety
3. Define the methods that can be used to study technology safety.

Conflict of Interest Declaration

- I do not have an affiliation (financial or otherwise) with a pharmaceutical, medical device, health care informatics organization, or other for-profit funder of this program.

DESIGNING HEALTH TECHNOLOGY SAFETY

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MICHAEL SMITH FOUNDATION FOR HEALTH RESEARCH

BC's health research funding agency

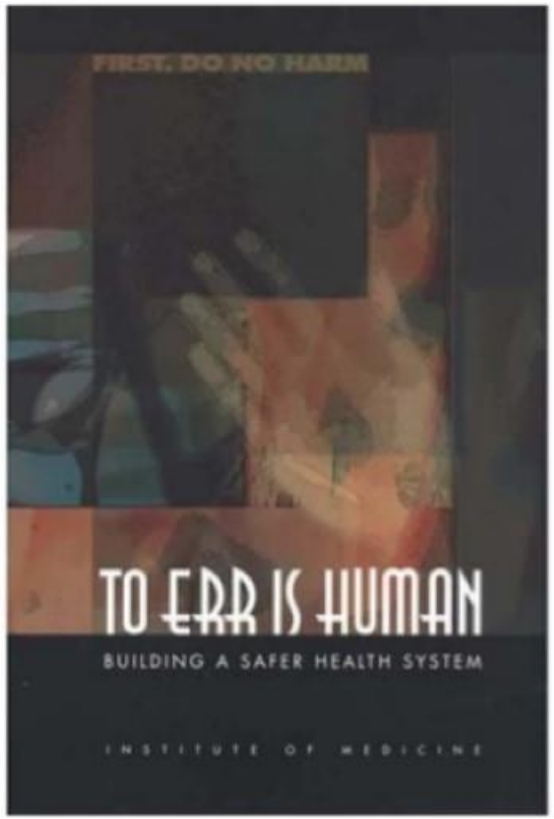
OUTLINE

1. Define Technology-induced Errors
2. Review Technology Safety Model
3. Review Methods for Studying Technology Safety
4. Future Directions in Health Informatics Research and Practice
   - Data Science
   - AI
   - Virtual Care
   - Smart Homes

To Err is Human
Institute of Medicine, 1999

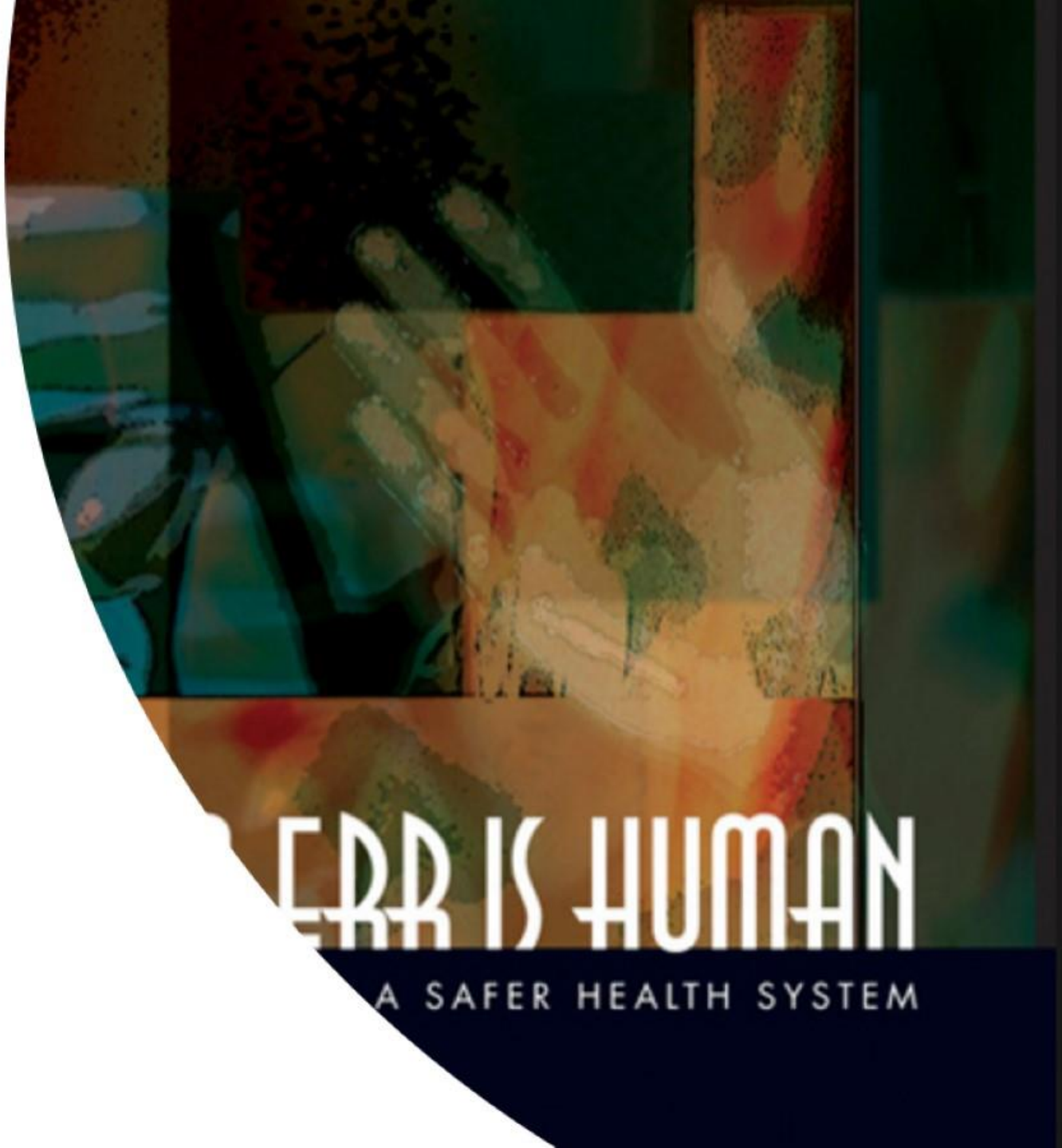
Up to 98,000 deaths annually due to medical errors.

Improvement goal: Reduce by 50% in 5 Years.



Background:
Health Information Systems Can Reduce Error Rates

- In North America policy recommendations were made to implement health information systems in physician and office settings to reduce medical error rates
    - ("To Err is Human", Institute of Medicine, 2000)



WITH NEW PROCESSES AND TECHNOLOGIES THERE ARE NEW SAFETY ISSUES

In 2004 research emerged suggesting technology could facilitate medical errors.

- (Kushniruk et al., 2004; Koppel et al., 2005;)

- Research also suggested technology has the ability to:
  - ***reduce medical errors***
- AND
  - ***introduce new types of errors***

- Main finding: ***Errors can have their origins in health information systems and technologies***
  - (Kushniruk et al., 2004; Koppel et al., 2005)

Technology-induced Errors

What is a technology-induced error?

What are Technology-induced Errors?

Technology-induced errors are errors that arise from the:

a) design and development of a technology,
b) its implementation and customization,
c) interactions between the operation of a technology and the new work processes that arise from a technology's use,
d) its maintenance, and
e) the interfacing of two or more technologies used to provide or support health care activities.

(Borycki et al., 2012; Kushniruk et al., 2005, 5, p. 388)

Examples: Technology-induced Errors

- Some **features and functions** of user interfaces are highly associated with error (Kushniruk et. al, 2005)
  - **Medication discontinuation failures** (Koppel et al., 2005)
  - **Auto-population of Fields with Defaults Information** (Ash et al., 2004; Borycki et al., 2005; Kushniruk et. al., 2004)

- **Documenting on the wrong patient record**
  - unable to determine what patient you are documenting on **due to screen colour and font size**
  - When **more than one patient record** is open, on the same screen health professionals may **inadvertently entering information into the wrong record**

    (Koppel et al., 2005)

Examples: Technology Induced Errors

- **Fragmenting patient information**

  (Borycki et al., 2005)

- **Layout and organization of information** affects diagnostic accuracy

  (Patel et. al, 2000)

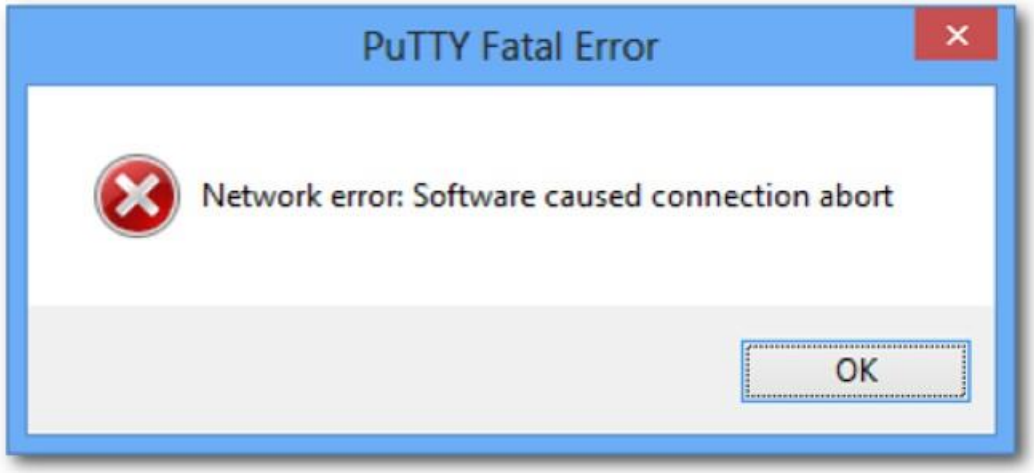
- Health professionals could become **"screen driven"**
  - could lead to **suboptimal clinical practice and may introduce diagnostic error** (Kushniruk et. al., 1996)

- May provide the **wrong information or instructions**
- May **miss symptoms**

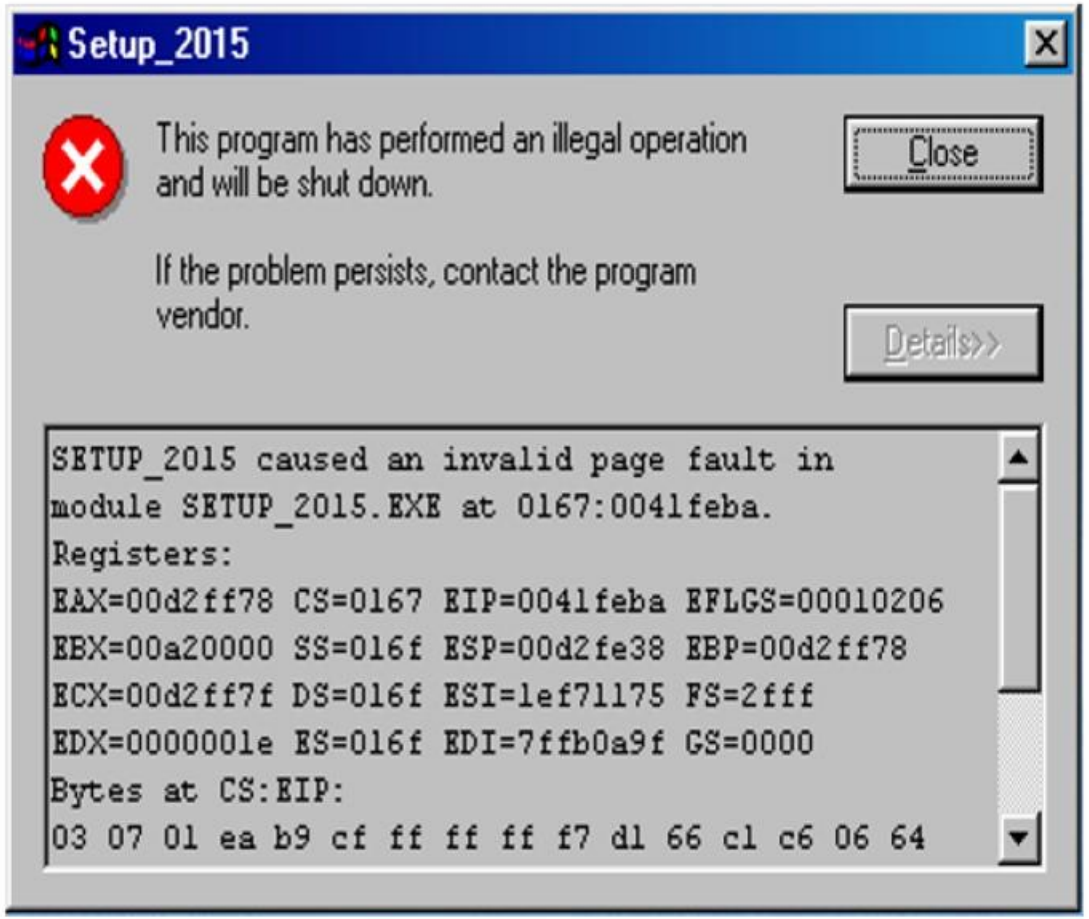
  (Fraser, Coiera,& Wong, 2018; Olson, 2018)

Technology-induced Errors

Have you observed one or been involved in one?



Complexity of Technology-induced Error



Technology Induced Errors

Incident Reports

Palojoki et al. 2017

In a fully digitized healthcare system in Finland:

- 23 hospitals
- 21,000 employees
- 50,000 patient visits annually

- She looked at Incident Reports over a 2 year period

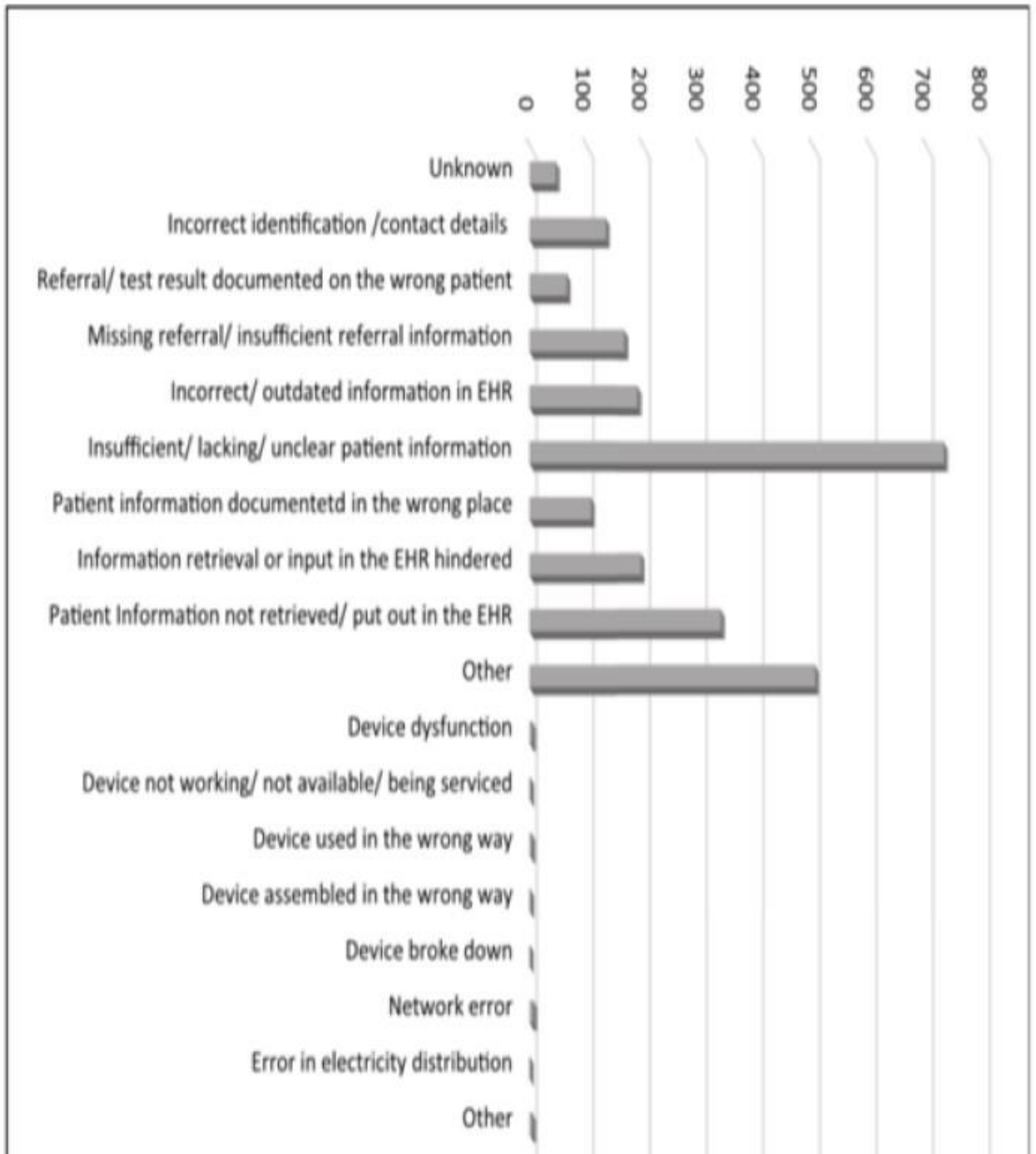
Palojoki, S., Pajunen, T., Saranto, K., & Lehtonen, L. (2016). Electronic health record-related safety concerns: a cross-sectional survey of electronic health record users. *JMIR medical informatics*, *4*(2), e13.

Findings

A range of errors were discovered and a number involve technology

Table 2. Classification of the problems.

(Type) problem	Frequency n = 117 (%) in AIMS database	Frequency n = 1971 (%) in HaiPro database
1. Information input problems	36 (31)	1415 (59.5)
2. (Machine) information transfer problems	23 (20)	210 (8.8)
3. Information output problems	23 (20)	342 (14.4)
4. (Machine) general technical	28 (24)	4 (0.17)



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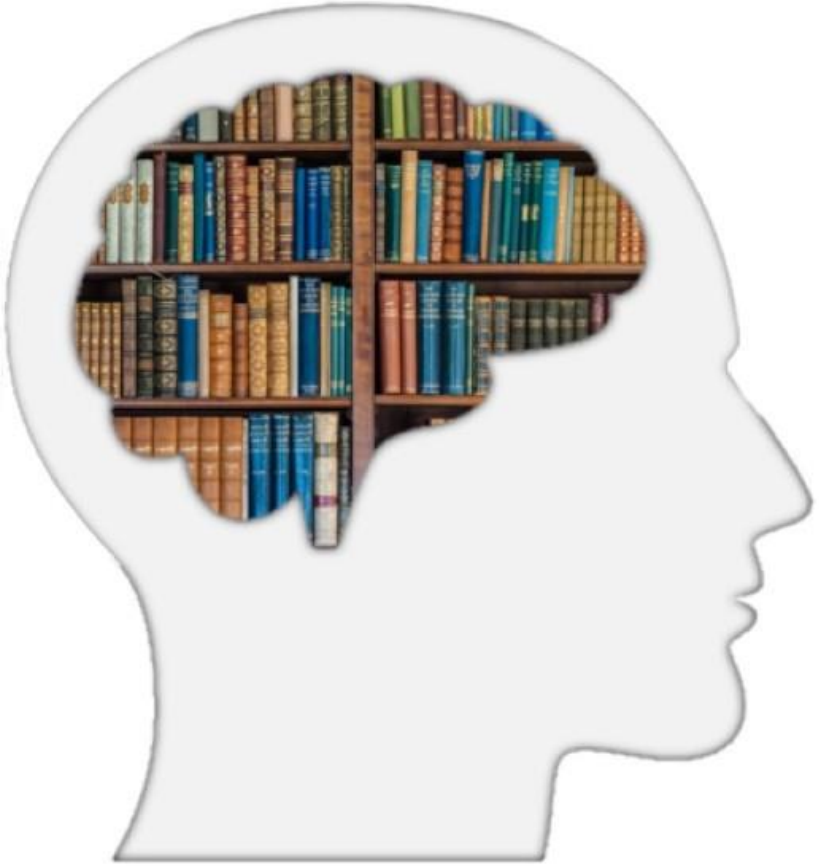
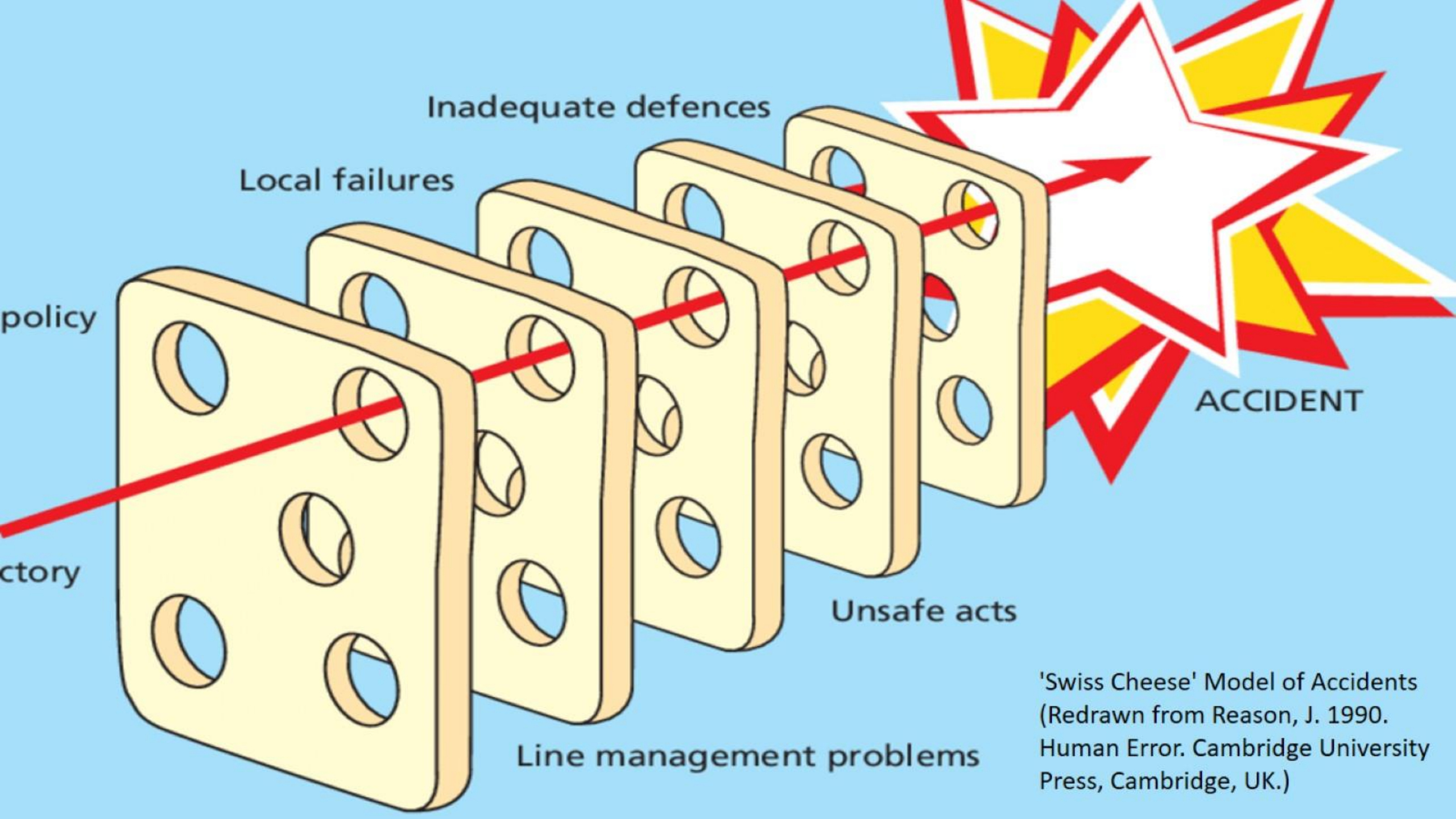
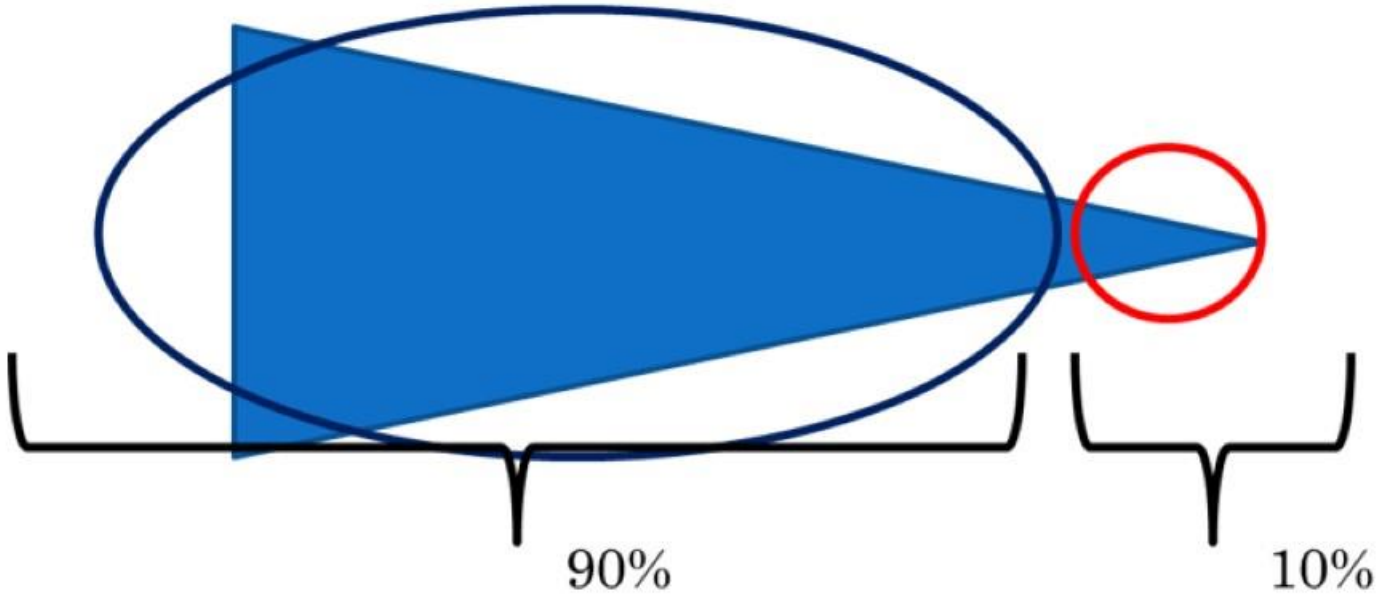
Models and Frameworks





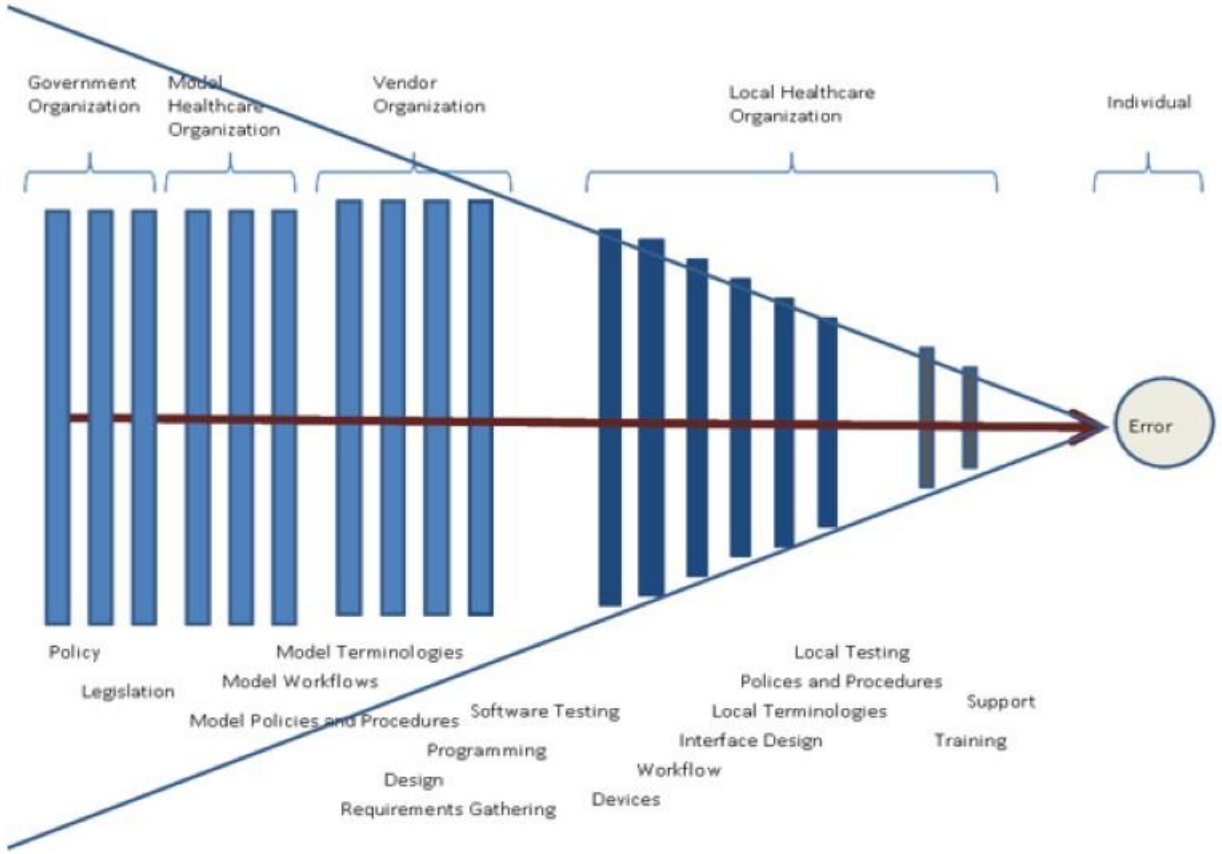
'Swiss Cheese' Model of Accidents (Redrawn from Reason, J. 1990. Human Error. Cambridge University Press, Cambridge, UK.)



Need for Health Information Technology Safety Research

- 90% of errors are system related (i.e. Blunt end errors) and 10% are human errors (i.e. Sharp end)
  - (Cavenaugh, 2006)
- Case has been made in the automotive, aviation and other industries
- Case needs to be made for technology-induced errors

Model of Technology Induced Error



Borycki, E. M., Kushniruk, A. W., Keay, L., & Kuo, A. (2009). A framework for diagnosing and identifying where technology-induced errors come from. *Studies in health technology and informatics*, *148*, 181–187.

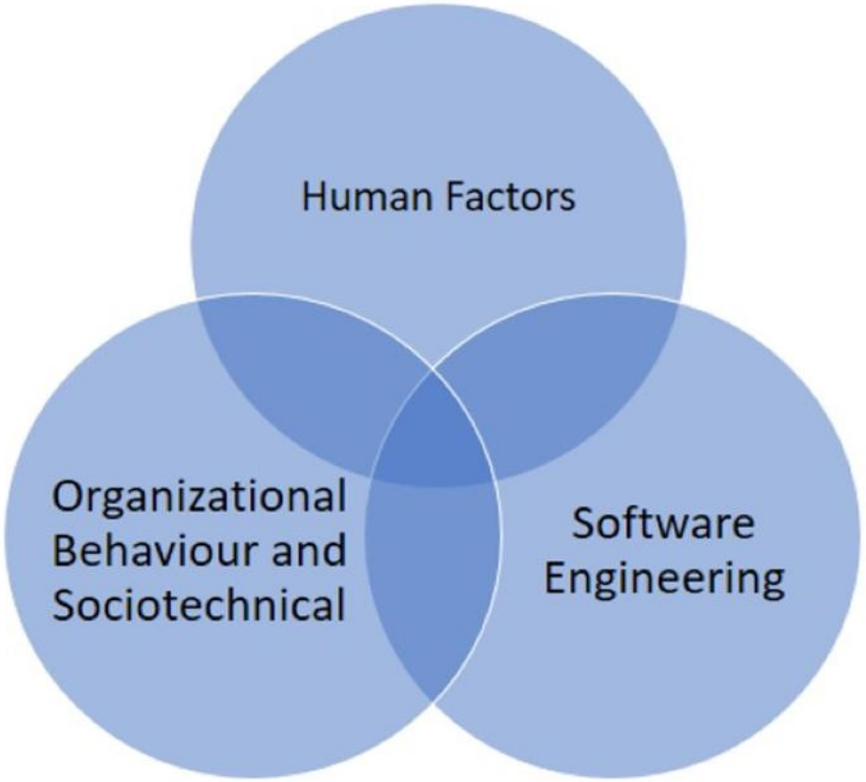
Frameworks and Models for Diagnosing Technology–induced Errors

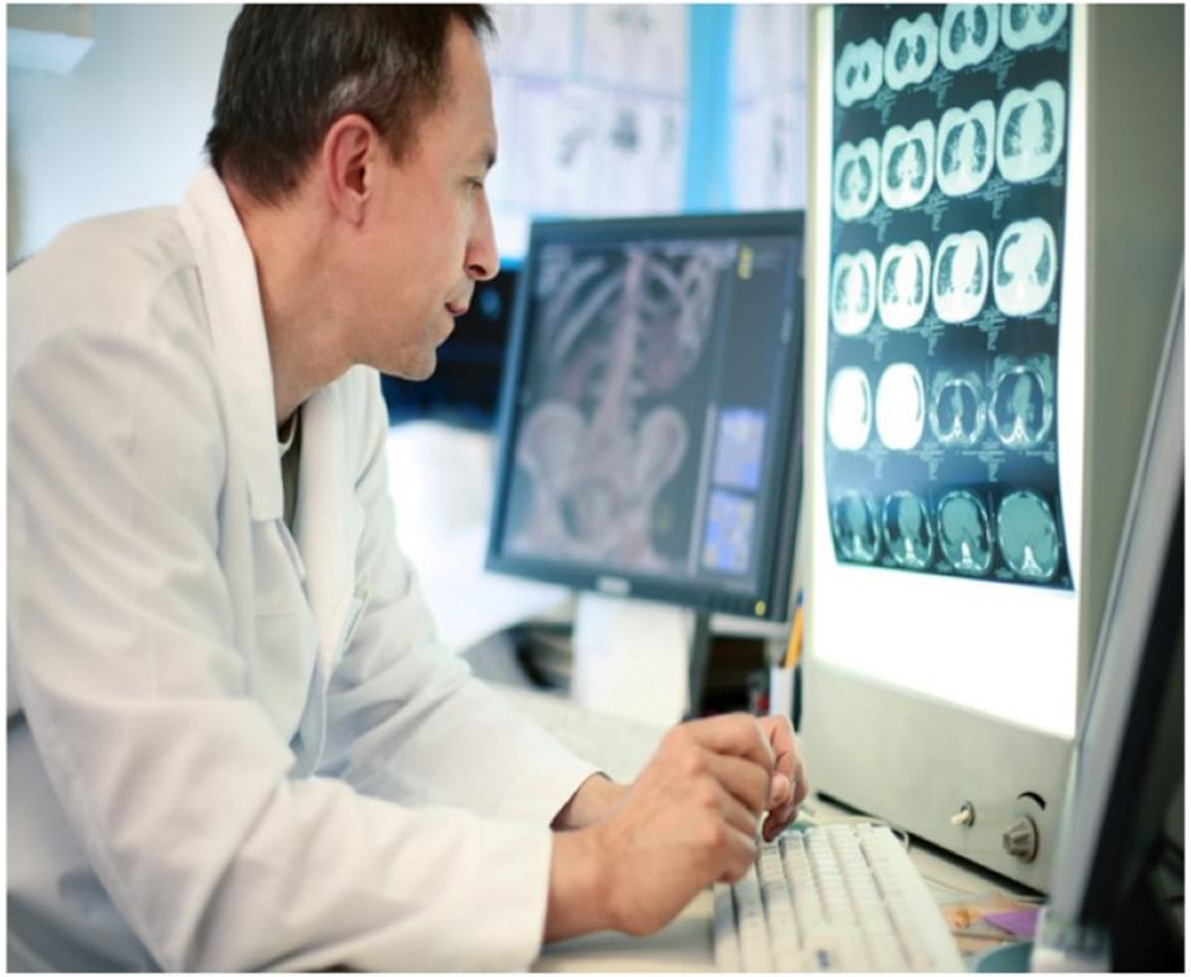
Borycki EM, Kushniruk AW, Bellwood P, Brender J. Technology-induced errors. The current use of frameworks and models from the biomedical and life sciences literatures. Methods Inf Med. 2012;51(2):95-103. doi: 10.3414/ME11-02-0009. Epub 2011 Nov 21. PMID: 22101488.

Table 1 Summary of articles

Authors/Year of Publication /Reference Number	Framework/Model	Potential Causes of Errors	Strengths and Weaknesses of the Frameworks/Models	Literatures of Origin	State of Current Application
Bloomrosen, Starren, Lorenzi, Ash, Patel and Shortliffe, 2011 [32]	Input-output model of unintended consequences	Interface design, implementation, poor training/support, poor fit with workflow, poor fit with decision making, interoperability, legistlative and regulatory changes, data accuracy	Strengths: based on expert consensus and recommendations. Weaknesses: provides a research agenda but not specific techniques	Organizational/Fiscal/ Policy and Regulation/ Cognitive and Human Factors	Proposes a research agenda
Borycki and Keay, 2010 [30]	Continuum of methods for diagnosing technology-induced errors	Interface design, poor system organization fit, poor workflow	Strengths: can be used to design a strategy for addressing technology-induced errors across the Software Development Life Cycle. Weaknesses: requires further testing.	Software Engineering/ Sociotechnical/Human Factors	Parts have been used in healthcare organizations (cites multiple empirical works in its development – e.g. Ash et al., 2007)
Kushniruk, Beuscart-Zephir, Grzes, Borycki, Watbledand Kannry, 2010 [29]	Framework for selecting health information systems to prevent error	Poor system-organization fit, poor procurement processes	Strengths: can be used for system selection. Weaknesses: difficult to change "conventional" methods currently used for system procurement	Software Engineering/ Project Management/ Sociotechnical Design/ Risk Management	Has been applied in various hospital settings
Sittig and Singh, 2010 [19]	Eight-dimensional model of sociotechnical challenges involved in	Poor system design, system development, or configuration	Strengths: considers multiple dimensions of safe and effective	Human Factors/Diffusion of Innovations/ Organizational Behav-	Has been applied and is undergoing further testing (See Sittig &

Frameworks and Models for Diagnosing Technology-induced Errors





Borycki EM, Kushniruk AW, Bellwood P, Brender J. Technology-induced errors. The current use of frameworks and models from the biomedical and life sciences literatures. Methods Inf Med. 2012;51(2):95-103. doi: 10.3414/ME11-02-0009. Epub 2011 Nov 21. PMID: 22101488.

How Do We Meaningfully Solve Technology-Induced Errors?

Methods for Addressing Technology-induced Errors

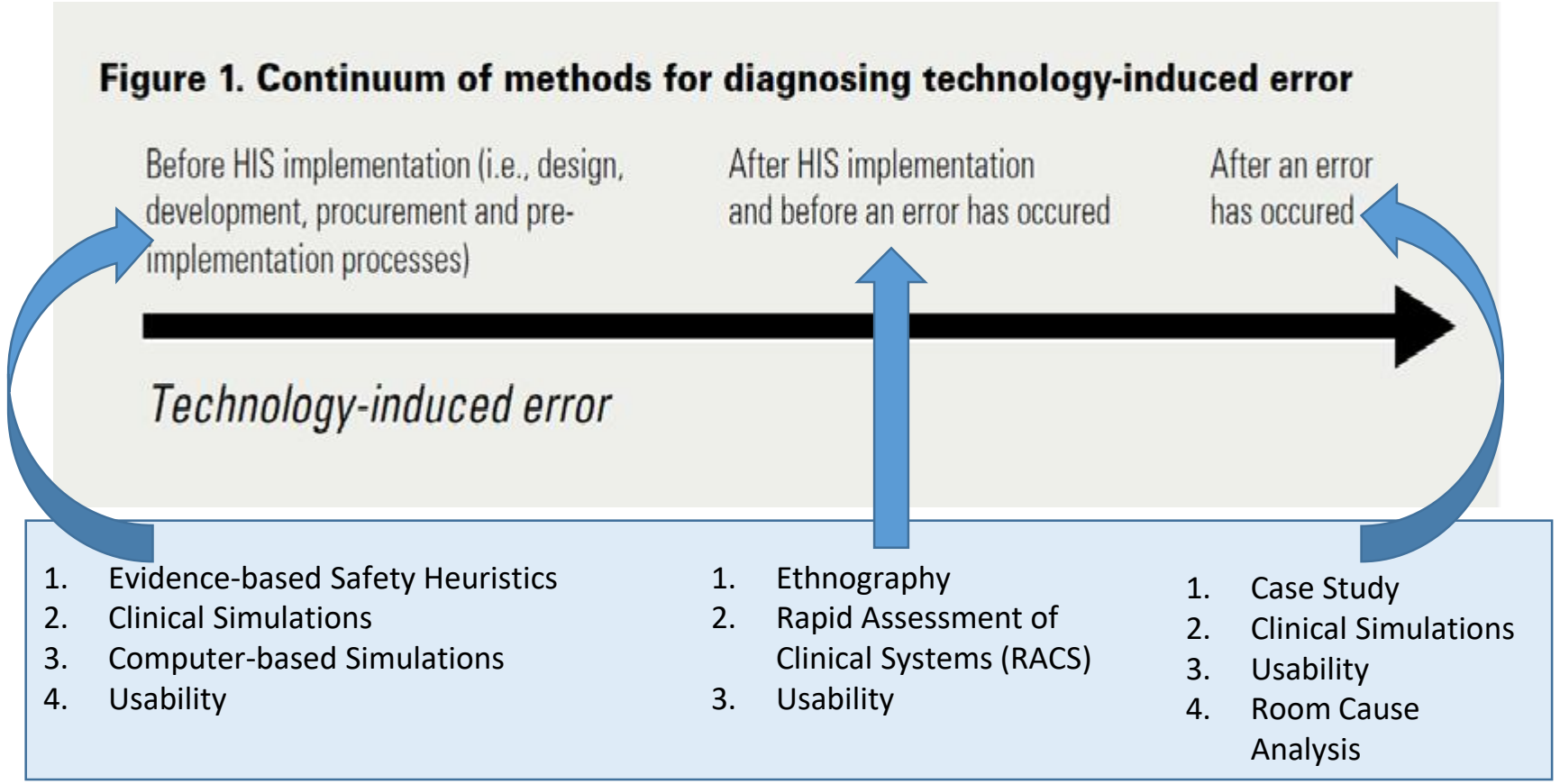
Methods for Diagnosing Technology-induced Error

- **Qualitative**
  - Describe and document technology-induced errors
  - Limitation of these methodologies
  - Little is known about the extent of the problem
  - (Borycki et al., 2009)

- **Quantitative**
  - Document the extent of the problem
  - Limitation of these methodologies:
  - Full range of technology-induced errors is as yet unknown
    - (Carvalho et al., 2009)

- **Mixed Methods**
  - Fewer studies
    - (Kushniruk et al., 2005)

Methods for Diagnosing Technology-induced Errors



Borycki E, Keay E. Methods to assess the safety of health information systems. *Healthc Q*. 2010;13 Spec No:47-52. doi:10.12927/hcq.2010.21966

Borycki, E., Dexheimer, J. W., Hullin Lucay Cossio, C., Gong, Y., Jensen, S., Kaipio, J., Kennebeck, S., Kirkendall, E., Kushniruk, A. W., Kuziemsky, C., Marcilly, R., Röhrig, R., Saranto, K., Senathirajah, Y., Weber, J., & Takeda, H. (2016). Methods for Addressing Technology-induced Errors: The Current State. Yearbook of medical informatics, (1), 30–40. https://doi.org/10.15265/IY-2016-029

Evidence-based Heuristics for Health Information Systems Safety

Workflow Issues

1. System does not change business process: increase work, decrease communication, increase time to complete the task
2. System does not inadvertently impose sequential ordering or parallel activity
3. Ability to override the system during emergencies
4. Minimal number of clicks for entering medication orders
5. Allow more than one person to view the record at the same time
6. Look out for inflexible screen sequences
7. Clear log-on and log-off
8. Consistency of information on computer and paper record in hybrid environments
9. System medication information is on the computer and is compatible with the paper records (e.g. if system goes down)
10. How accommodating is the system when clinicians perform physical activities

Safeguards

1. Interaction checking: drug-drug, drug-dilutent, drug-IV
2. System checks for duplicate medications, IV drugs, and procedures
3. Alerts and reminders should be consistent with current organizational policies and procedures
4. Appropriate level of locking the record and record fields
5. All allergy and reminder information does not lead to high false positive rates
6. Displays indicate normal range of doses
7. Patient's room is displayed appropriately to ensure no error by giving the patient the wrong medication
8. Content heuristic 3

Carvalho, C. J., Borycki, E. M., & Kushniruk, A. (2009). Ensuring the safety of health information systems: using heuristics for patient safety. *Healthcare quarterly (Toronto, Ont.)*, *12 Spec No Patient*, 49–54. https://doi.org/10.12927/hcq.2009.20966

Content Issues

1. Medications should be listed in terms of priority where appropriate (e.g. stat meds should be on top)
2. Medication status is clearly displayed
3. Medication lists and synonyms have been properly customized to the hospital
4. Clearly display date and time medication was updated
5. Drug information should be guideline based
6. Limit or do not use defaults for medications unless they are clear on their applicability
7. Origin of defaults should be clear to the users (e.g. organization suggested or vendor default)
8. Entry and updating of rules that guide alerts, reminders, etc. are up to date and controlled appropriately
9. Information about one drug order should be on the same screen when possible (i.e. limit number of screen transactions for the same order)
10. Safeguard heuristic 6
11. Ensure medication information in EHR is consistent with information on other parallel systems.
12. Workflow heuristic 8
13. Work flow heuristic 9
14. Safeguard heuristic 7

Functional Issues

1. Allow for linkages between ordering medication and IT discontinuation
2. Allow for linkages between ordering procedures, medication, and discontinuation procedures and medication
3. Menus are scrollable and clearly marked as such
4. Signals the person who is ordering the medication when the first dose will be given for all non-standard orders, procedures, medication doses, etc.
5. Allow for notes or annotations regarding special conditions, etc.
6. Limit free-text that others may not be able to see

Usability: Before, During, and After Implementation

Figure 1. Video recording of a subject interacting with health information systems during a clinical simulation

Borycki, E., Kushniruk, A., Nohr, C., Takeda, H., Kuwata, S., Carvalho, C., Bainbridge, M., & Kannry, J. (2013). Usability Methods for Ensuring Health Information Technology Safety: Evidence-Based Approaches. Contribution of the IMIA Working Group Health Informatics for Patient Safety. *Yearbook of medical informatics*, *8*, 20–27.

Kushniruk, A., & Borycki, E. (2017). Low-Cost Rapid Usability Testing: Its Application in Both Product Development and System Implementation. Studies in health technology and informatics, 234, 195–200.

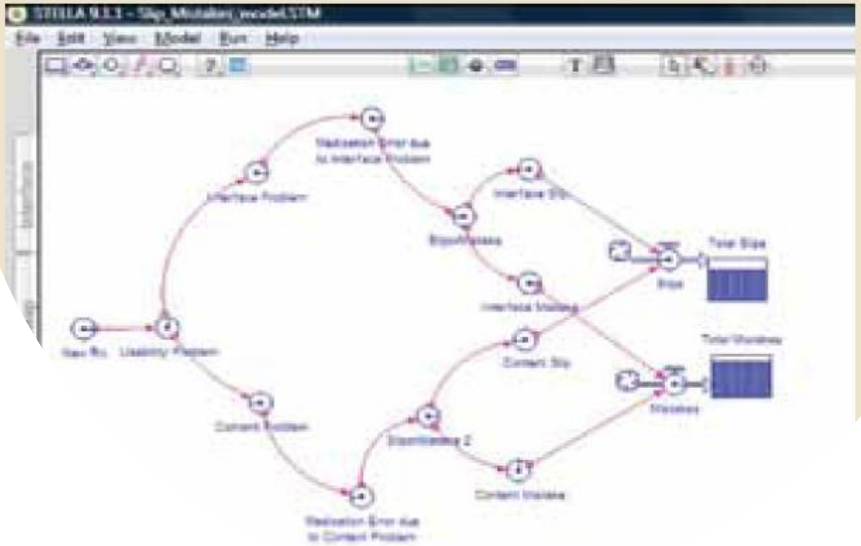
Clinical Simulations

Kushniruk, A., Nohr, C., Jensen, S., & Borycki, E. M. (2013). From Usability Testing to Clinical Simulations: Bringing Context into the Design and Evaluation of Usable and Safe Health Information Technologies. Contribution of the IMIA Human Factors Engineering for Healthcare Informatics Working Group. *Yearbook of medical informatics*, *8*, 78–85.

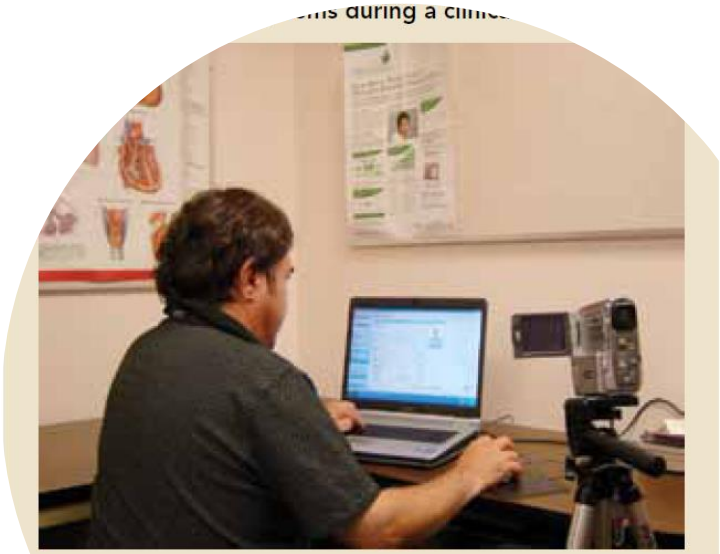
Clinical Plus Computer-based Simulations

- Extension of computer based simulations
- Clinical simulations are used as input parameters to a computer-based simulation model

Figure 2. Computer-based mathematical models of technology-induced error

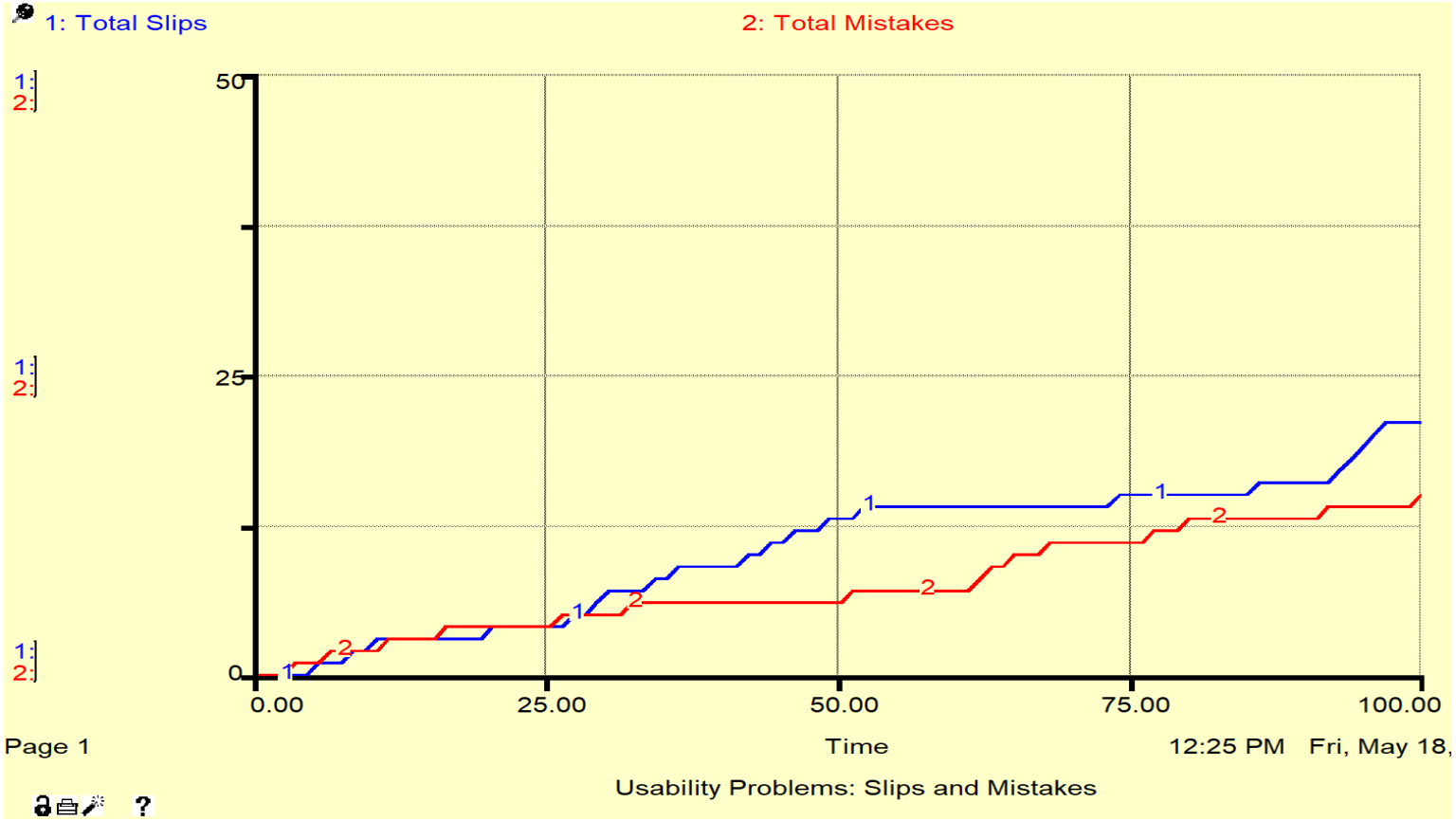


- **Risk Management:**
  - Prevention of errors
  - Influence system customization
  - Development of policies and procedures
  - Health professional training
  - Alert to error causing properties of the technology



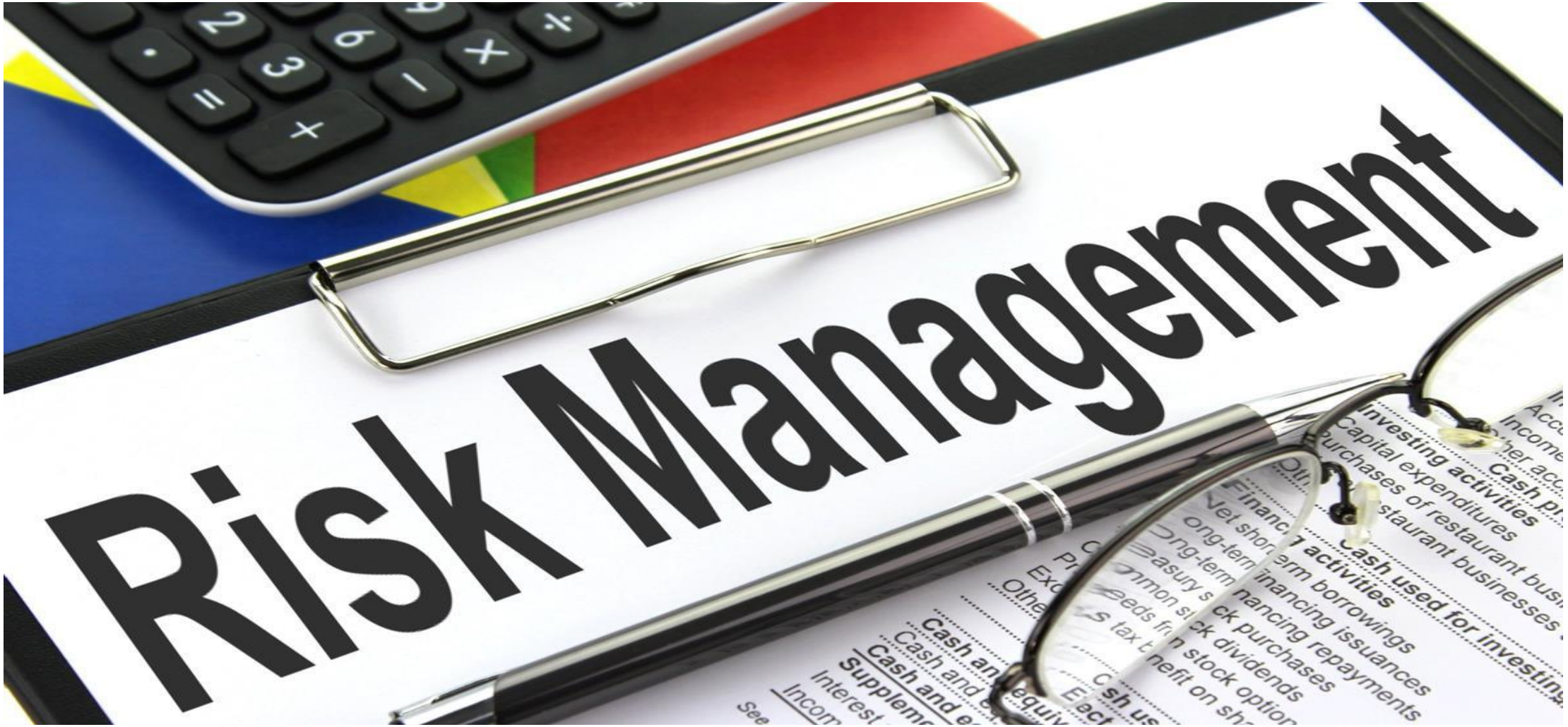
Borycki, E. M., Kushniruk, A., Keay, E., Nicoll, J., Anderson, J., & Anderson, M. (2009). Toward an integrated simulation approach for predicting and preventing technology-induced errors in healthcare: implications for healthcare decision-makers. *Healthcare quarterly (Toronto, Ont.)*, *12 Spec No Patient*, 90–96. https://doi.org/10.12927/hcq.2009.20974

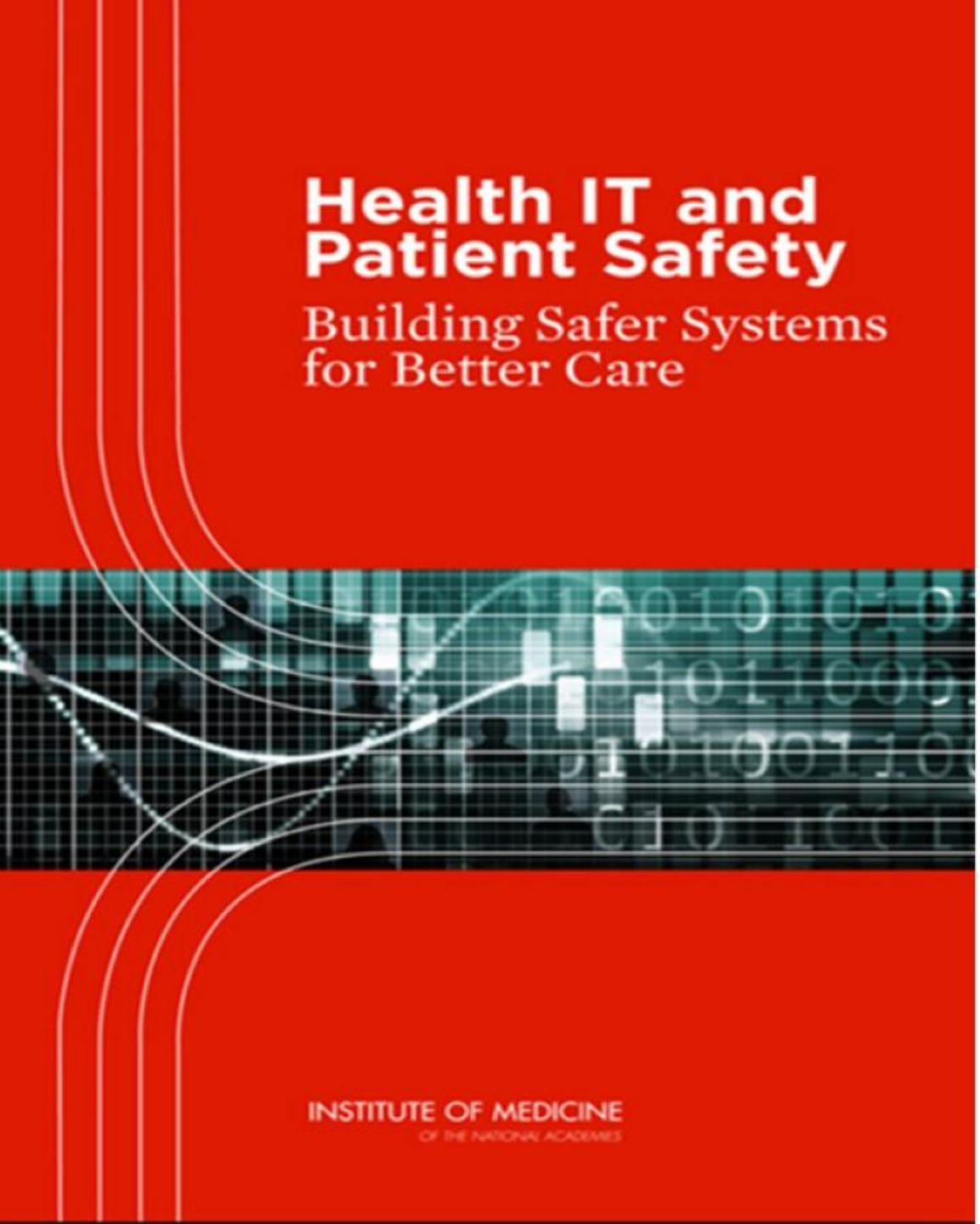
Clinical Plus Computer-based Simulations



Borycki, E. M., Kushniruk, A., Keay, E., Nicoll, J., Anderson, J., & Anderson, M. (2009). Toward an integrated simulation approach for predicting and preventing technology-induced errors in healthcare: implications for healthcare decision-makers. *Healthcare quarterly (Toronto, Ont.)*, *12 Spec No Patient*, 90–96. https://doi.org/10.12927/hcq.2009.20974

Risk Management





- *"To achieve better health care…proactive steps must be taken to ensure that health information technology is developed and implemented with safety as a primary focus"*

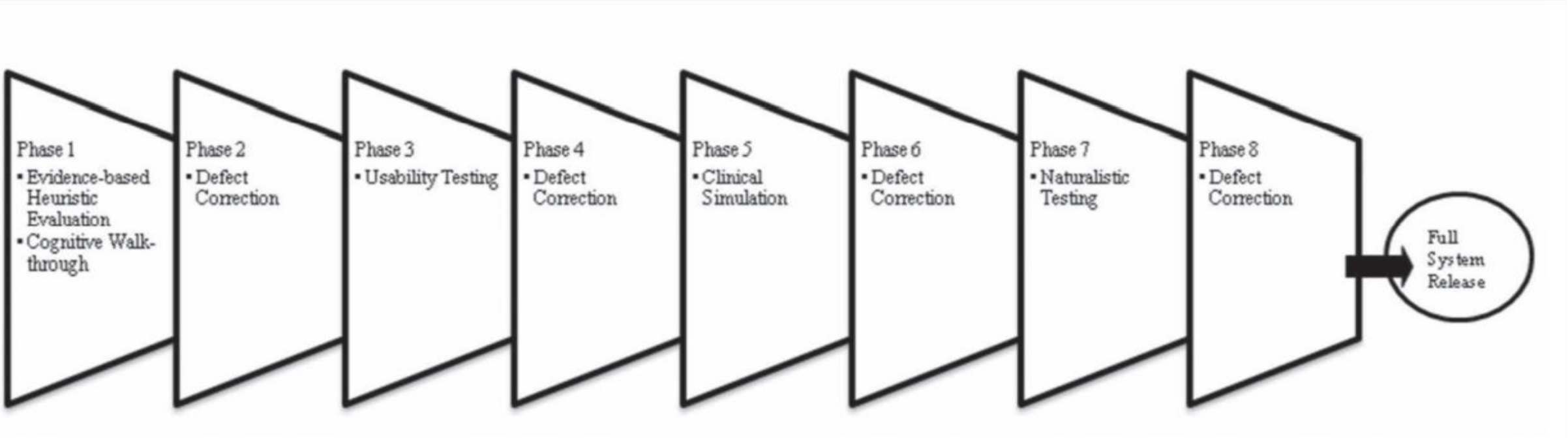
(Institute of Medicine, 2012)

IMPROVING DIAGNOSIS IN HEALTH CARE

- Health system **complexity** has increased with the introduction of health IT
- Technology is affecting **diagnosis and decision-making** of health professionals
- Technology-induced errors need to be **prevented**

How do you Manage Risk?

Take a Layered Approach

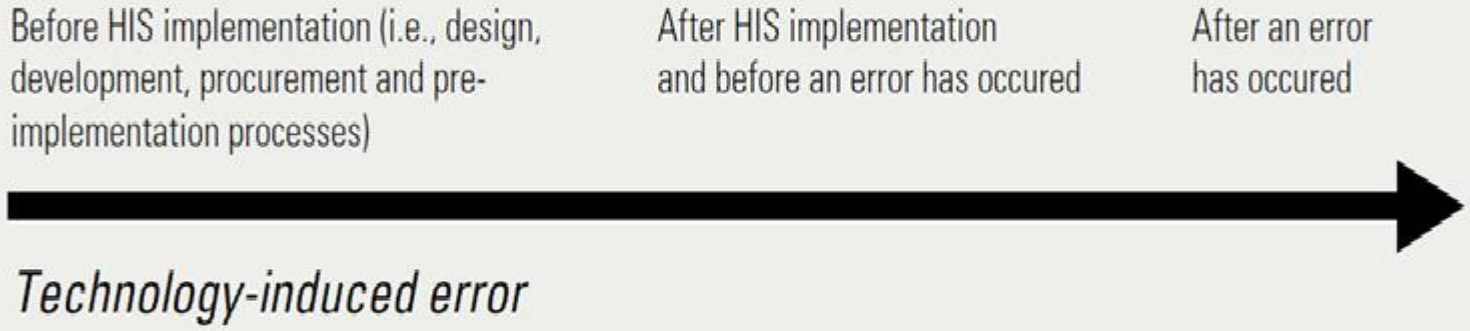


ig. 3 Phases of System Testing Incorporating Usability Testing with Clinical Simulation and Naturalistic Testing

Borycki, E., Kushniruk, A., Nohr, C., Takeda, H., Kuwata, S., Carvalho, C., ... & Kannry, J. (2013). Usability methods for ensuring health information technology safety: evidence-based approaches contribution of the IMIA working group health informatics for patient safety. Yearbook of medical informatics, 22(01), 20-27.

Develop a Testing Plan

Figure 1. Continuum of methods for diagnosing technology-induced error



1. Evidence-based Safety Heuristics	1. Ethnography	1. Case Study
2. Clinical Simulations	2. Rapid Assessment of Clinical Systems (RACS)	2. Clinical Simulations
3. Computer-based Simulations	3. Usability	3. Usability
4. Usability		4. Room Cause Analysis

Borycki E, Keay E. Methods to assess the safety of health information systems. *Healthc Q*. 2010;13 Spec No:47-52. doi:10.12927/hcq.2010.21966

Borycki, E., Dexheimer, J. W., Hullin Lucay Cossio, C., Gong, Y., Jensen, S., Kaipio, J., Kennebeck, S., Kirkendall, E., Kushniruk, A. W., Kuziemsky, C., Marcilly, R., Röhrig, R., Saranto, K., Senathirajah, Y., Weber, J., & Takeda, H. (2016). Methods for Addressing Technology-induced Errors: The Current State. Yearbook of medical informatics, (1), 30–40. https://doi.org/10.15265/IY-2016-029

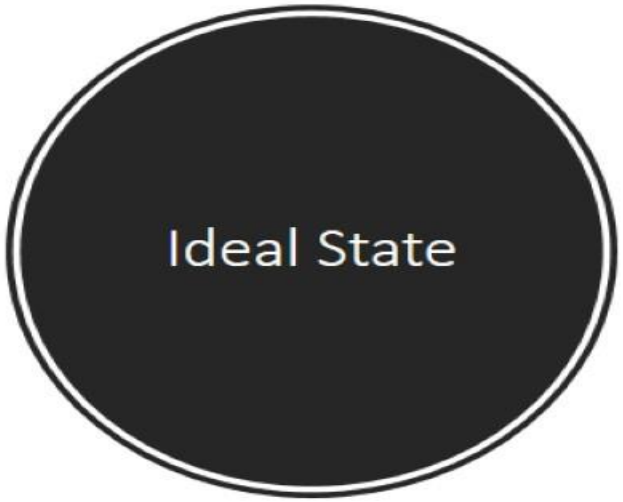
Training

Health Informatics Professionals are involved in:

- Safe Design and Development
- Models to Understand Errors and Promote Safety
- Risk Management
  - Prevention
  - Conducting investigations
  - Training
  - Guidelines
    - Developed in Canada and other countries
- Developing a Safety Culture

Kushniruk, A. W., Bates, D. W., Bainbridge, M., Househ, M. S., & Borycki, E. M. (2013). National efforts to improve health information system safety in Canada, the United States of America and England. International journal of medical informatics, 82(5), e149-e160.
Borycki, E. (2013). Trends in health information technology safety: from technology-induced errors to current approaches for ensuring technology safety. *Healthcare informatics research*, *19*(2), 69.

Safety will Improve Over Time



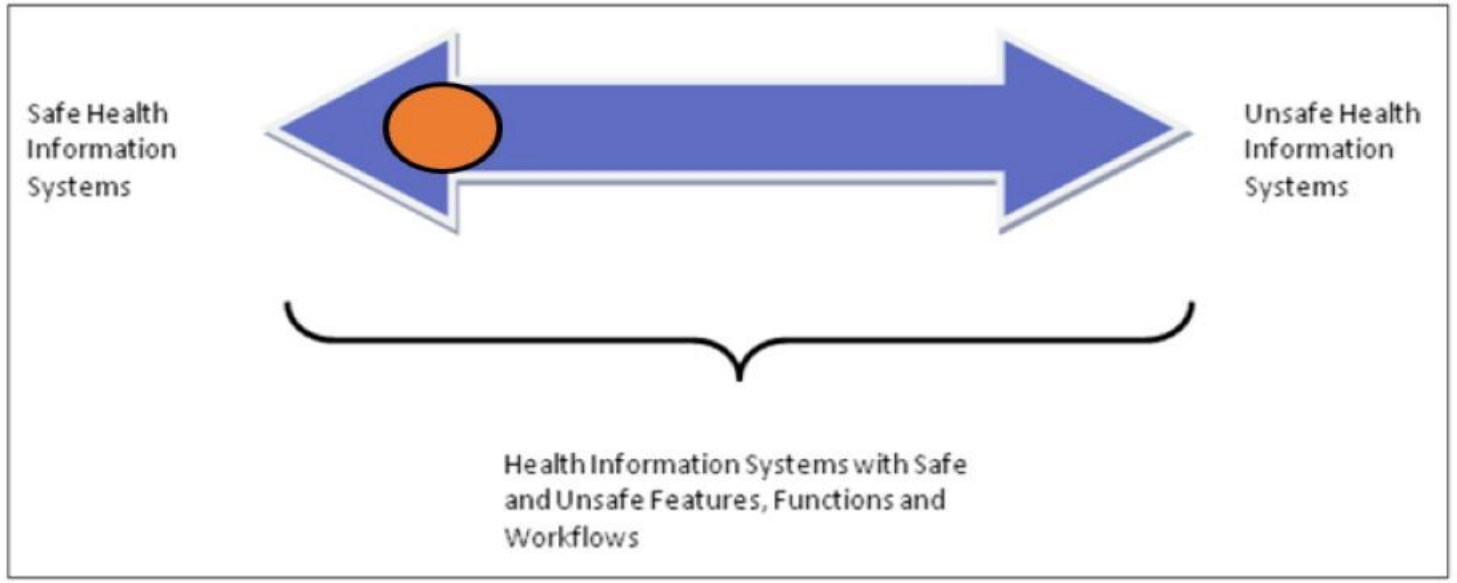


Fig. 1 Continuum of Health Information Systems Safety

Borycki, E. M., Househ, F. M. S., Kushniruk, A. W., Nohr, C., & Takeda, H. (2012). Empowering patients: making health information and systems safer for patients and the public. *Yearbook of medical informatics*, *21*(01), 56-64.

Risk Management

- Areas of Research Internationally
  - Safe HIT Design
  - Safe HIT Implementation
  - Reporting Technology-induced Errors
  - Technology-induced Error Analysis
  - HIT Risk Management

Methods for Addressing Technology-induced Errors: The Current State

Introduction

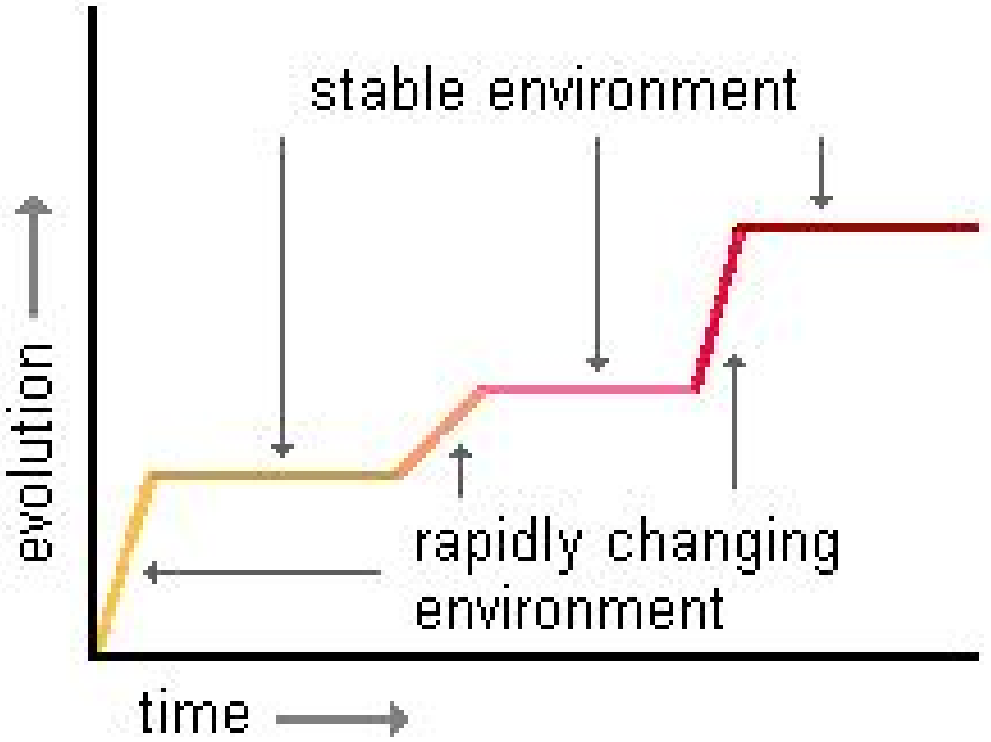
Healthcare has been and is Currently Undergoing Considerable Changes

- Many of changes are being driven by technologies.

- We are moving past traditional technologies such as the electronic health record and bar coded medication administration systems to those that will ***re-engineer how we provide patient care and with that we are developing new ways of conducting work***

Disruptive Technologies will Change Healthcare as We Know It

- Disruptive technologies and their mode of integration into health care are currently being explored
- New processes will need to be designed
- Outcomes may change
- New role and responsibilities are emerging for health professionals and patients



Loch, C. H., & Huberman, B. A. (1999). A punctuated-equilibrium model of technology diffusion. *Management science*, *45*(2), 160-177.

Integrating Research into Health Informatics Education and Modernize Practice

NSERC Training Program: Visual and Automated Disease Analytics

TRAIN THE NEXT GENERATION

The Visual and Automated Disease Analytics (VADA) graduate training program is a joint initiative between the University of Manitoba and University of Victoria.

The VADA Program aims to train the next generation of health informatics and computational science graduate students to translate complex health data into insights that can be used to improve the health of populations and support health professional decision making. Through the VADA Program, trainees will gain cutting-edge data visualization and analytic skills within a cooperative and experiential learning environment.

OUR MISSION & VISION

To meet the need for analytics specialists who have knowledge of disease etiologies, transmission patterns as well as advanced analytic techniques in areas such as data mining and predictive analytics. Our graduates will have the skills to effectively and efficiently detect, manage, and prevent outbreaks associated with infectious diseases or to measure and predict healthcare utilization and health outcomes for patients with complex chronic conditions.

The VADA Program will prepare students for leadership roles in provincial and national ministries of health, in areas such as system performance, quality improvement, and surveillance. Graduates of the program are also desirable to private sector companies that focus on the development of innovative health-related data collection, management, mining and monitoring tools. Students will also be prepared for academia within emerging interdisciplinary departments that are building programs in data science and advanced analytics.

More About the Program

Canada's Digital Supercluster Project: Artificial Intelligence

CANADA'S DIGITAL TECHNOLOGY SUPERCLUSTER

PROGRAMS UPDATES & MEDIA ABOUT US MEMBERS JOIN RESOURCE PORTAL

Dermatology Point-of-Care Intelligent Network

AI-powered medical imaging network to connect all points of care for patients who may be dealing with skin cancer.

Project Budget* - $9.9

Partner Co-investment - $6.2M

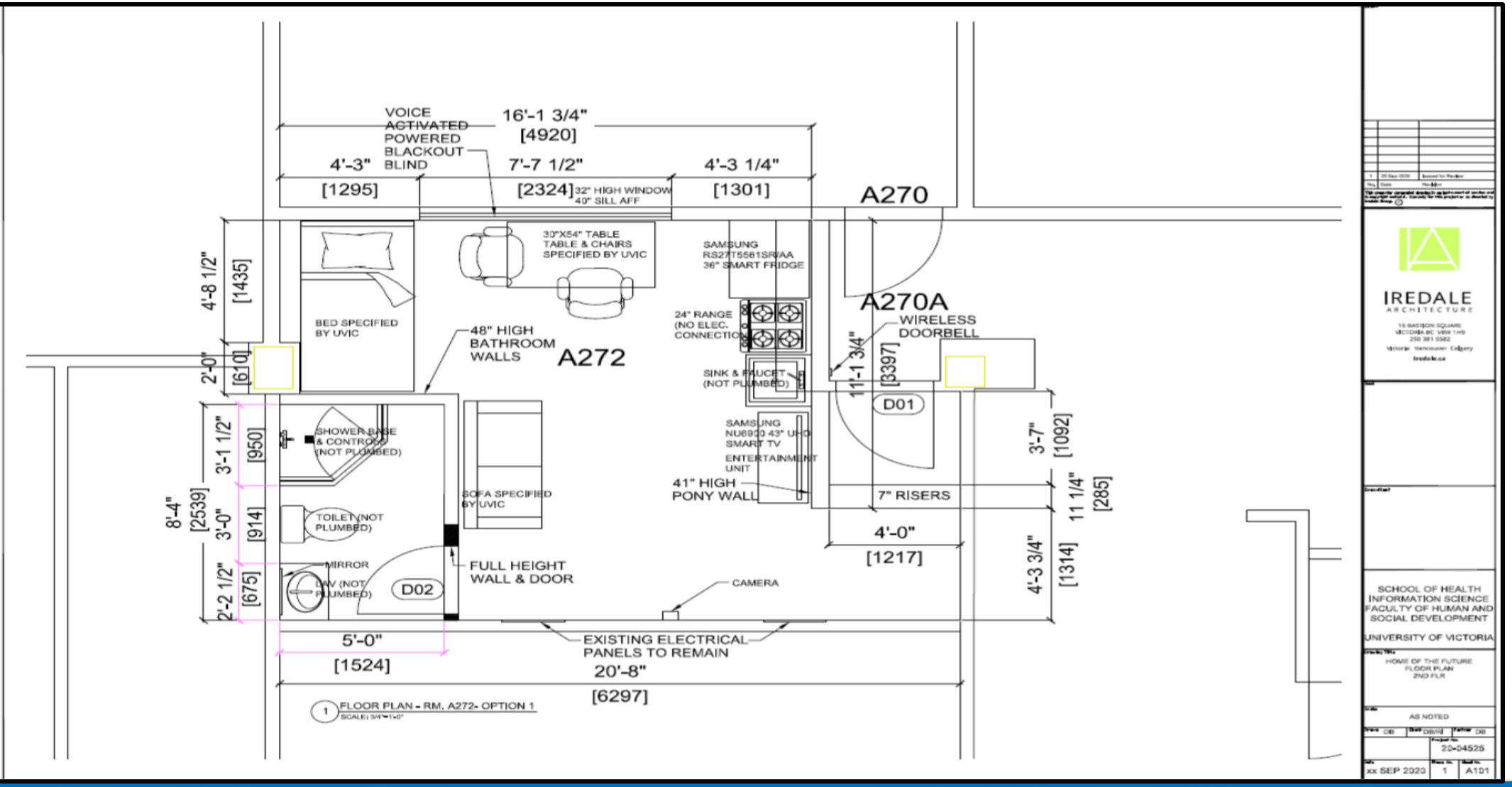
Supercluster Co-investment - $3.6M

Virtual Care

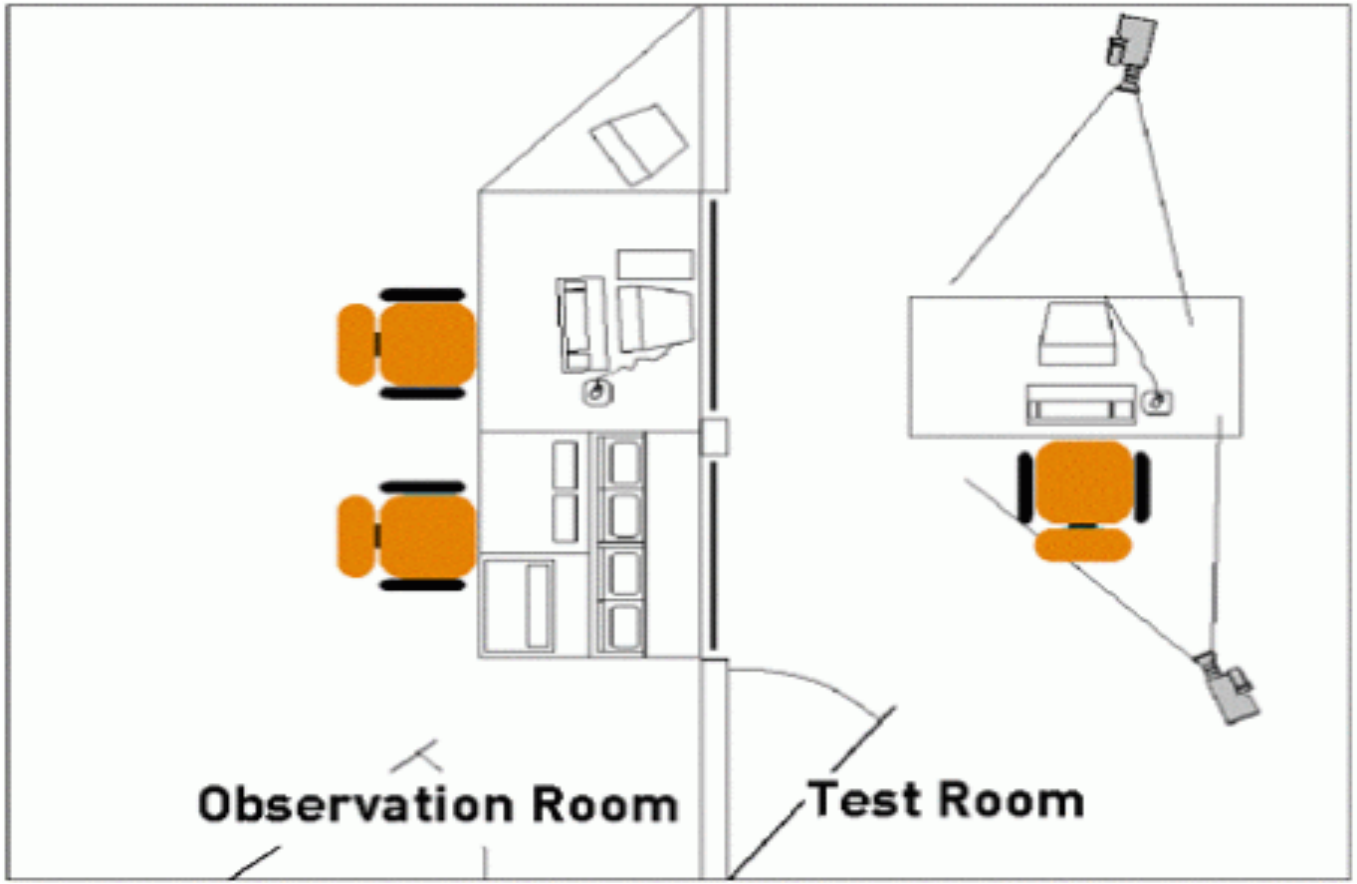
- Hospital at Home
- Telehealth
- Telemedicine
- Mobile Health
- Sensing Devices
- Intelligent Homes & Smart Homes
- Ambient Assistive Living
- Assistive Technologies
- Models of Digital Care
- Human Factors of Virtual Care
- Data Visualization
- Systems and Device Usability

Smart Homes, Intelligent Spaces and Context Aware Systems

Smart Homes, Intelligent Spaces and Ambient Assistive Living

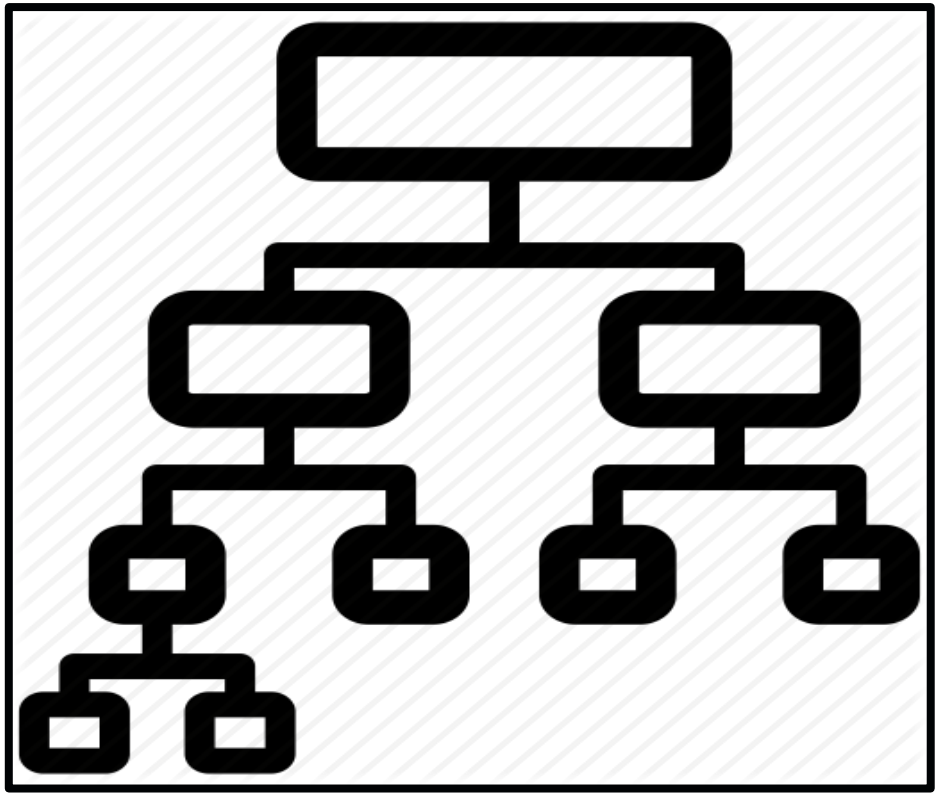


Usability Testing Lab

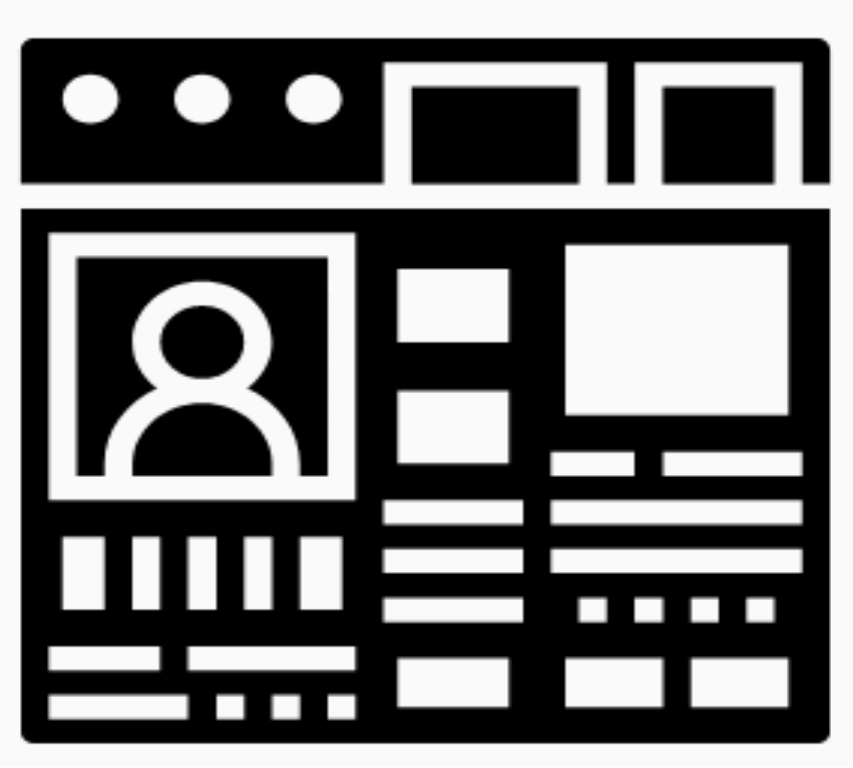


Safety Science

Classification Systems



Guidelines for Safe Design and Configuration of Systems



In the Fintech Element Glyph 000025 Collection

TECHNOLOGY SAFETY AND RISK MANAGEMENT

Publications related to health information technology safety and it's implications on health care and patient care delivery.

RELATED RESOURCES

E PRESCRIBING

Publications related to eprescribing and health care practices.

RELATED RESOURCES

ELECTRONIC MEDICATION RECONCILIATION

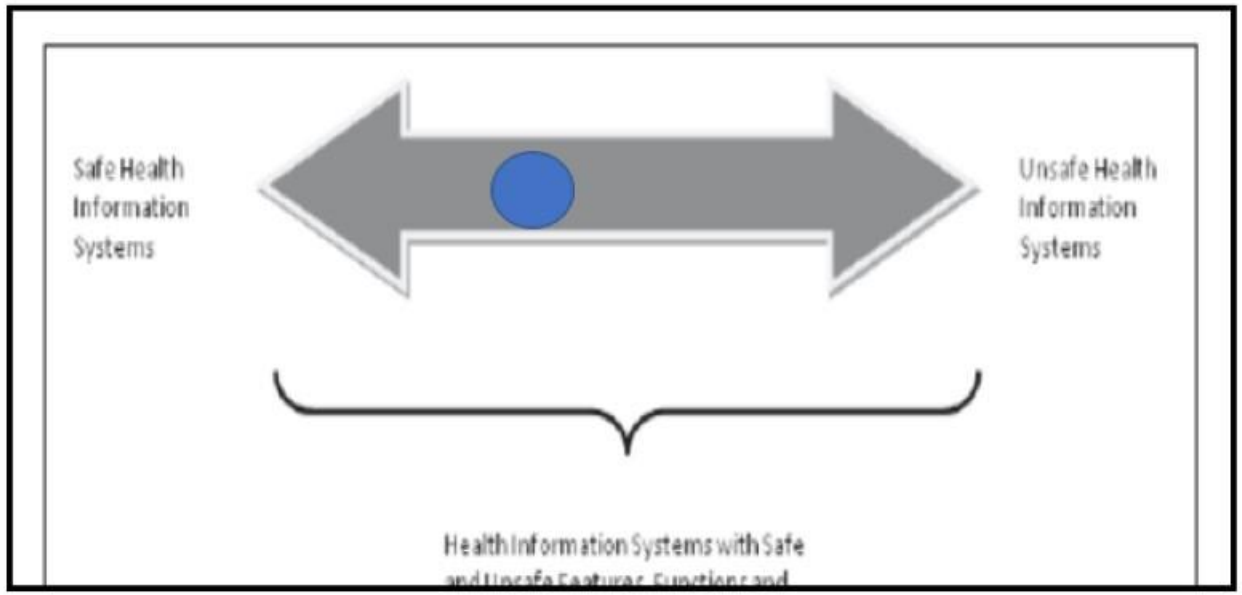
Design and development of technologies used to reconcile medications.

RELATED RESOURCES

GLOBAL LABORATORY FOR DIGITAL HEALTH INNOVATION

https://onlineacademiccommunity.uvic.ca/laboratoryfordigitalinnovationinhealth

Continuum of Health Information Systems Safety



(Borycki et al., 2009)

Key Points

- Technology can improve safety
- Safety systems science is evolving and optimizing technologies
- Health informatics research is advancing safety science
- Health informatics research and practice is extending to:
  - Data Science and AI
  - Virtual Care
  - Bringing the Hospital to the Home
  - Smart Homes, Intelligent Environments and Context Aware Systems

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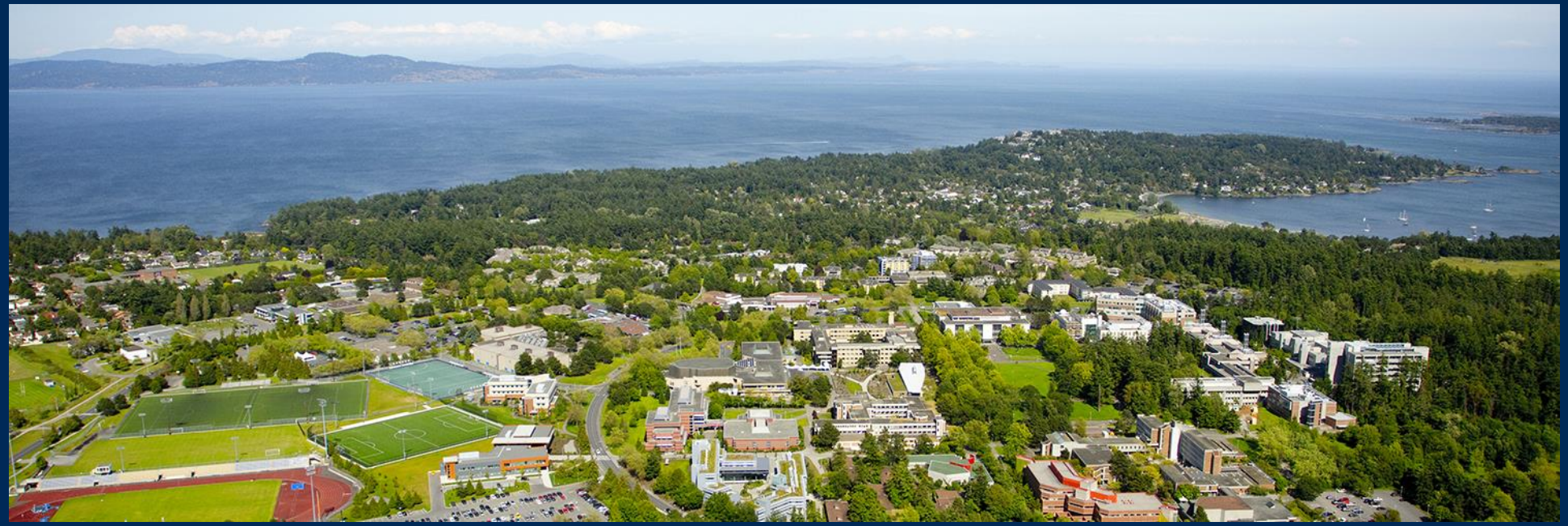
SCHOOL OF HEALTH INFORMATION SCIENCE



Celebrating 40 years of
Excellence in Health Informatics
Education

University of Victoria

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Thank you for attending today's event.