

A decorative background featuring a light blue grid. Several squares are highlighted: a solid orange square, a small square with blue diagonal lines, a larger square with blue diagonal lines, and a small square with red diagonal lines next to a solid pink square.

# ALGORITHMS IN HEALTHCARE CONTEXTS

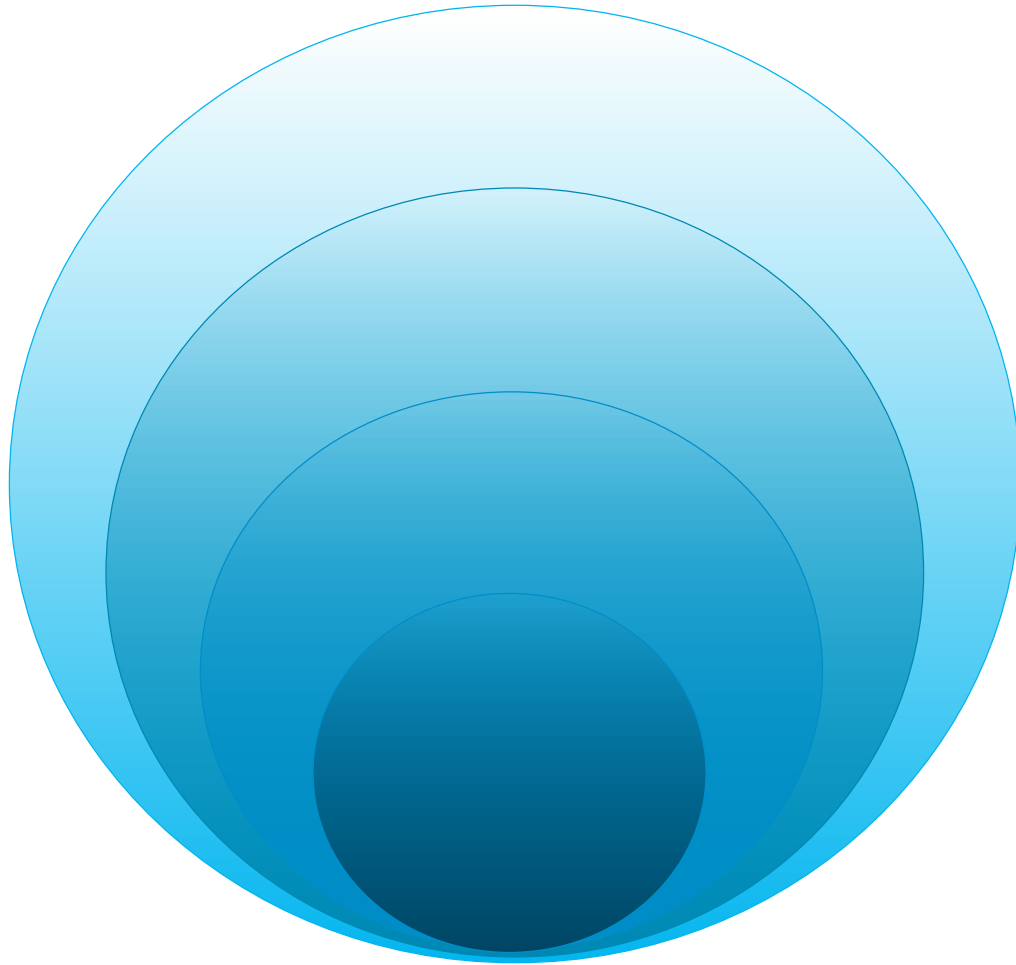
ETHICS AND RESPONSIBILITIES

**HCL**  
HOSPICES CIVILS  
DE LYON

22/05/2023 ANTOINE RICHARD, CHARGÉ DES APPLICATIONS IA, DSN HCL

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## ALGORITHMS, AI, MACHINE LEARNING, AND DEEP LEARNING



### Algorithms:

Mathematical methods to automatize a process, largely used in computer sciences to implement software

### Artificial Intelligence:

Sub-domain of computer sciences dedicated to reproduce « intelligent » skills into softwares<sup>1</sup>

### Machine Learning:

Sub-domain of artificial intelligence dedicated to create algorithms able to learn from data how to perform a task<sup>2</sup>

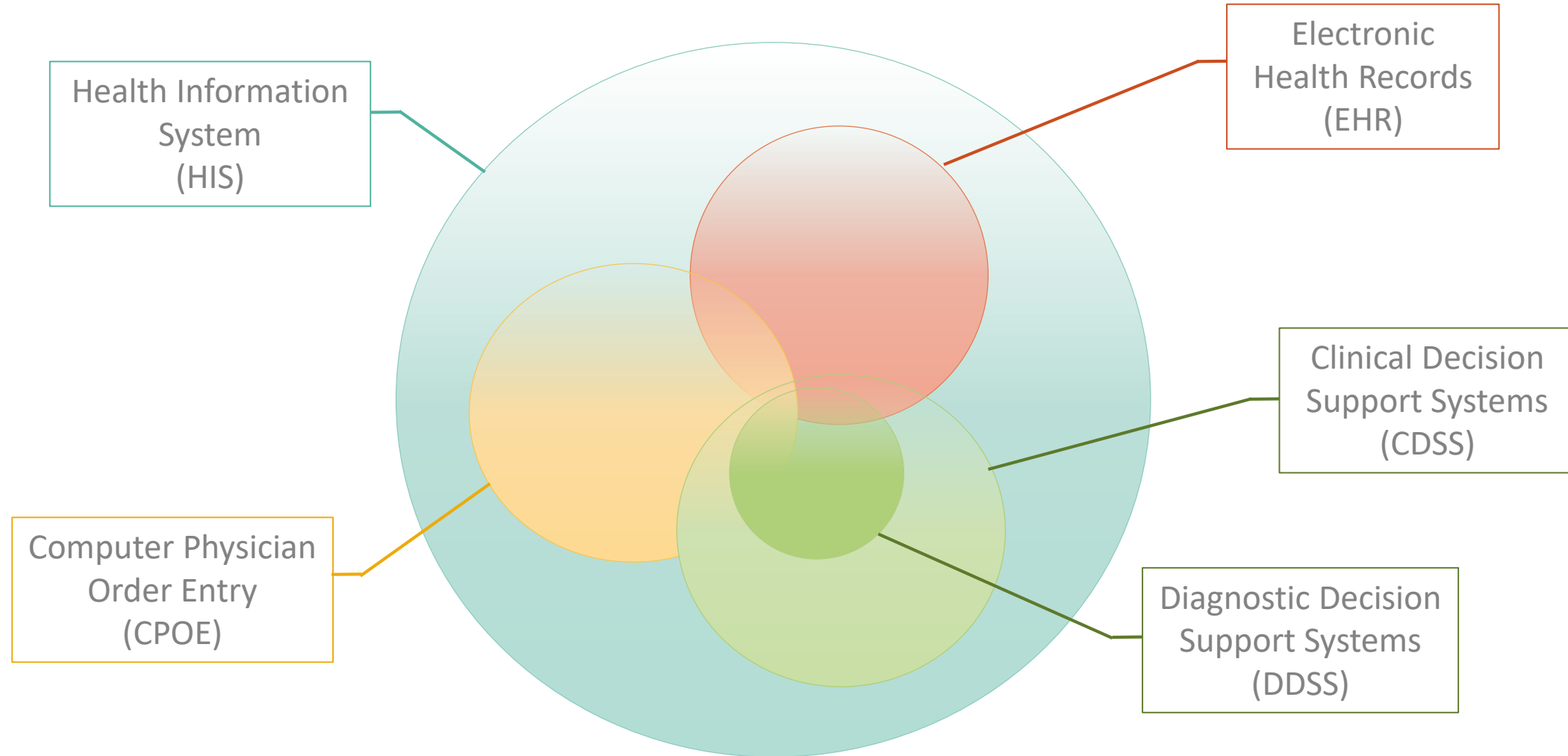
### Deep Learning:

Sub-domain of machine learning dedicated to multi-layer artificial neural networks<sup>3</sup>

1. [Gao and Ding \(2022\) - The research landscape on the artificial intelligence: a bibliometric analysis of recent 20 years](#)
2. [Mahesh \(2020\) – Machine Learning Algorithms: a review](#)
3. [Dong, Wang and Abbas \(2021\) – A Survey on Deep Learning and its Applications](#)

# DEFINITIONS

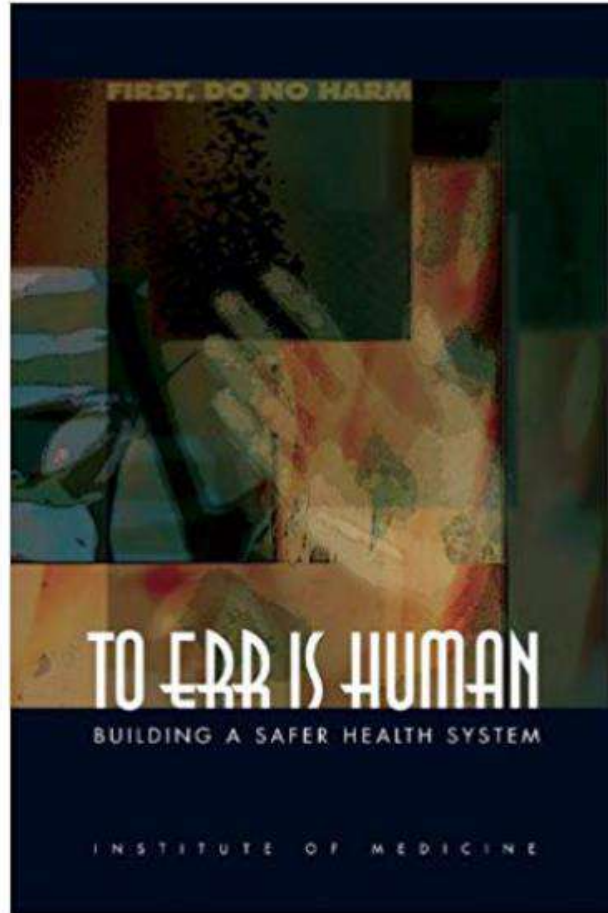
## HEALTH INFORMATION SYSTEMS <sup>1</sup>



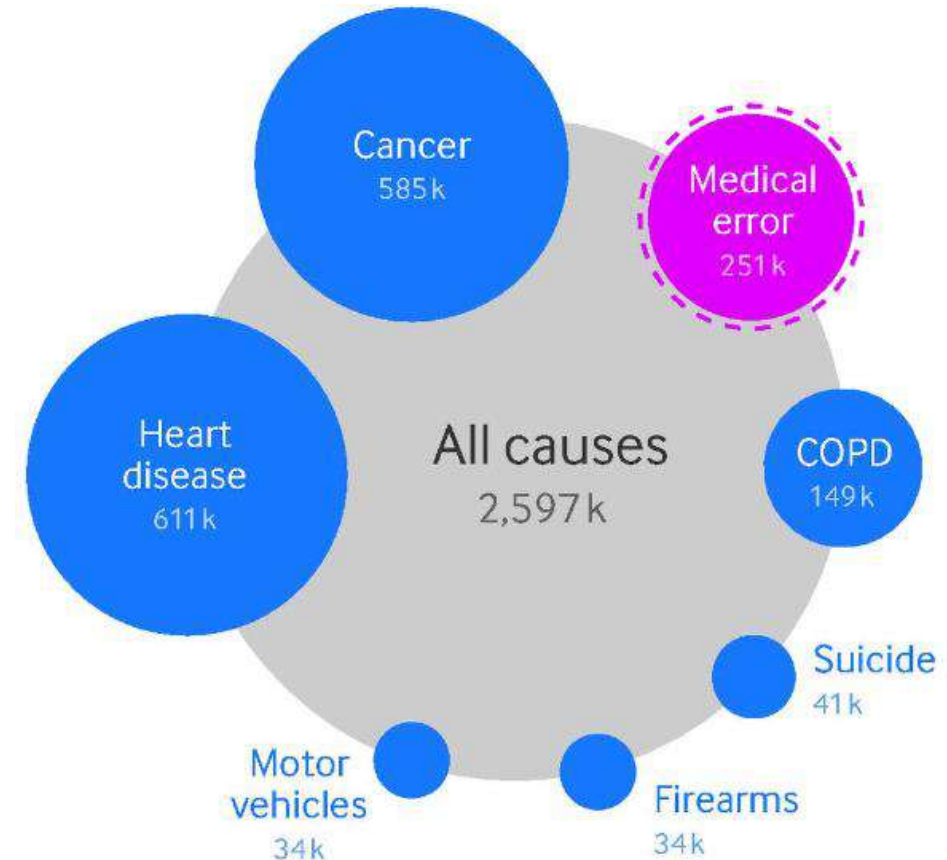
# WHY DEVELOPING HIS?

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## TACKLE MEDICAL ERRORS



Between 44k and 98k death in the US in 1997 <sup>1</sup>

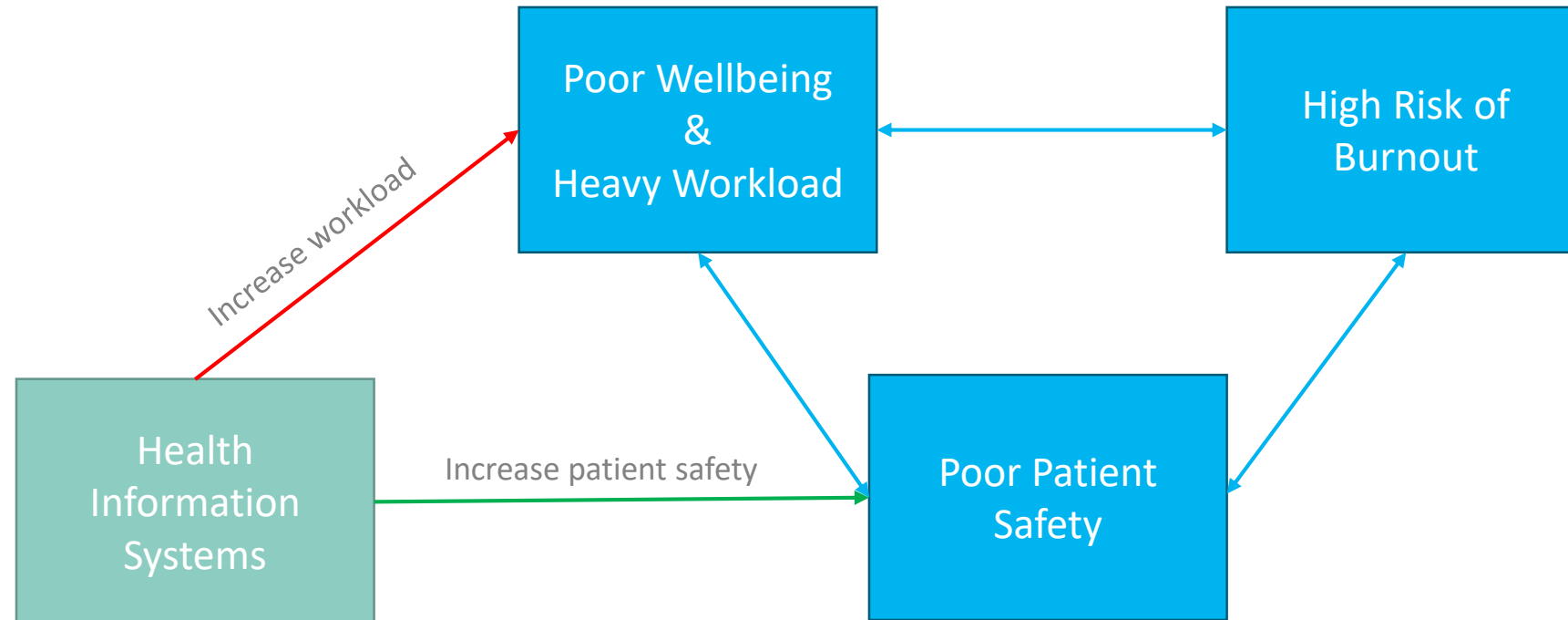


The third cause of death in the US in 2013 <sup>2</sup>

1. [Donaldson et al. \(2000\) – To err is human: building a safer health system](#)
2. [Makary and Daniel \(2016\) – Medical error : the third leading cause of death in the US](#)

# IMPACTS AND LIMITS OF HIS

## WORKLOAD AND PATIENT SAFETY: A VICIOUS CIRCLE <sup>1 2 3 4</sup>



1. [Hall et al. \(2016\) – Healthcare Staff Wellbeing, Burnout, and Patient Safety: A Systematic Review](#)
2. [Tawfik et al. \(2018\) – Physician Burnout, Well-being, and Work Unit Safety Grades in Relationship to Reported Medical Errors](#)
3. [West, Dybrye and Shanafelt \(2018\) – Physician burnout: contributors, consequences and solutions](#)
4. [Dutheil et al. \(2019\) – Suicide among physicians and health-care workers: A systematic review and meta-analysis](#)

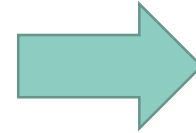
## ISO STANDARDS



### ISO 13485:

Quality management systems & Requirements for regulatory purposes

<https://www.iso.org/standard/59752.html>



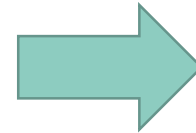
Applicable to AI ? <sup>1 2 3</sup>



### ISO 62304:

Medical device software & Software life cycle processes

<https://www.iso.org/standard/38421.html>



Under development :

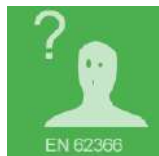
- [ISO 18988](#) : Application of AI technologies in health informatics
- [ISO 24029](#) : Assessment of the robustness of neural networks
- [ISO 5259](#) : Data quality for analytics and machine learning (ML)



### ISO 14971:

Application of risk management to medical devices

<https://www.iso.org/standard/72704.html>



### ISO 62366:

Application of usability engineering to medical devices

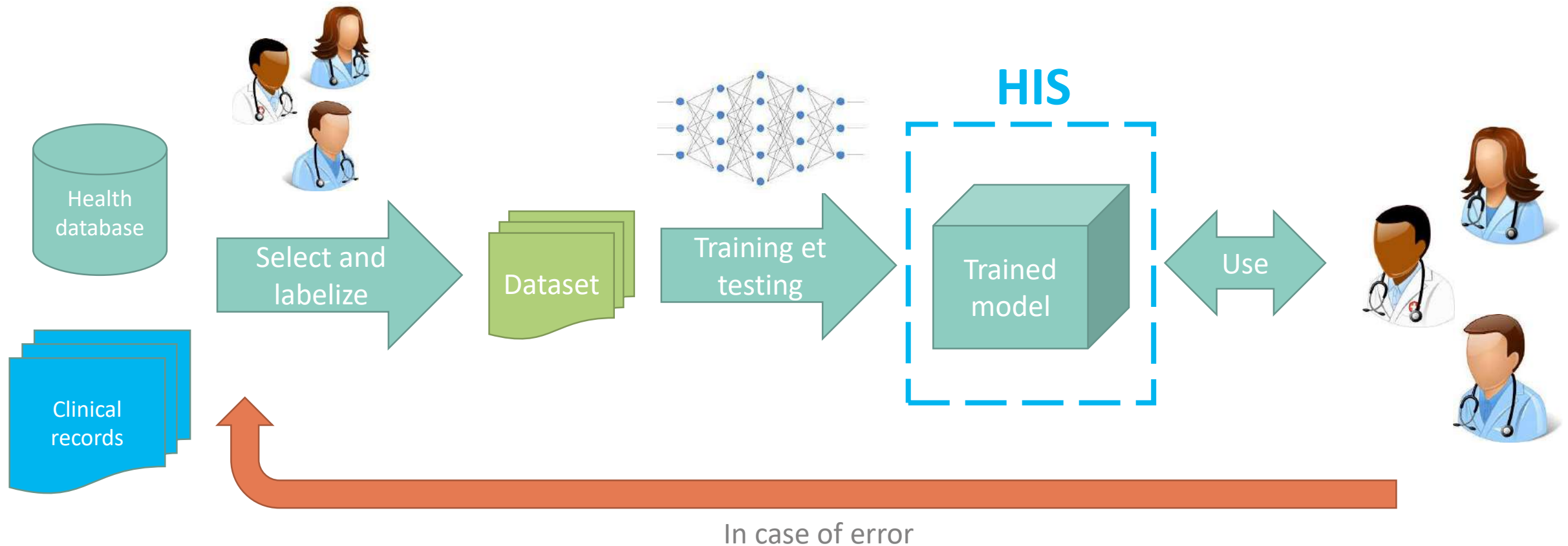
<https://www.iso.org/standard/63179.html>

1. [O'Sullivan et al. \(2018\) – Legal, regulatory, and ethical frameworks for development of standards in artificial intelligence \(AI\) and autonomous robotic surgery](#)
2. [Zhao \(2019\) – Improving Social Responsibility of Artificial Intelligence by Using ISO 2600](#)
3. [Natale \(2022\) – Extensions of ISO/IEC 25000 Quality Models to the Context of Artificial Intelligence](#)

# AI IN HEALTHCARE

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## A SECOND WAVE OF COMPUTERIZATION



## IN SHORT, MEDIUM AND LONG TERMS

### Reproduction of discriminative behaviors <sup>1</sup>

AI tends to reproduce, or even amplify, discriminative behaviors present in its training dataset

### Loss of physicians' skills and know-how <sup>2 3</sup>

Physicians do not necessarily detect errors from AI, especially if the AI presents high performances and physicians have strong confidence in the AI

### Negative « rebound effect » on physicians and/or patients <sup>4</sup>

The use of new technologies could conduct in unexpected transformations in healthcare processes

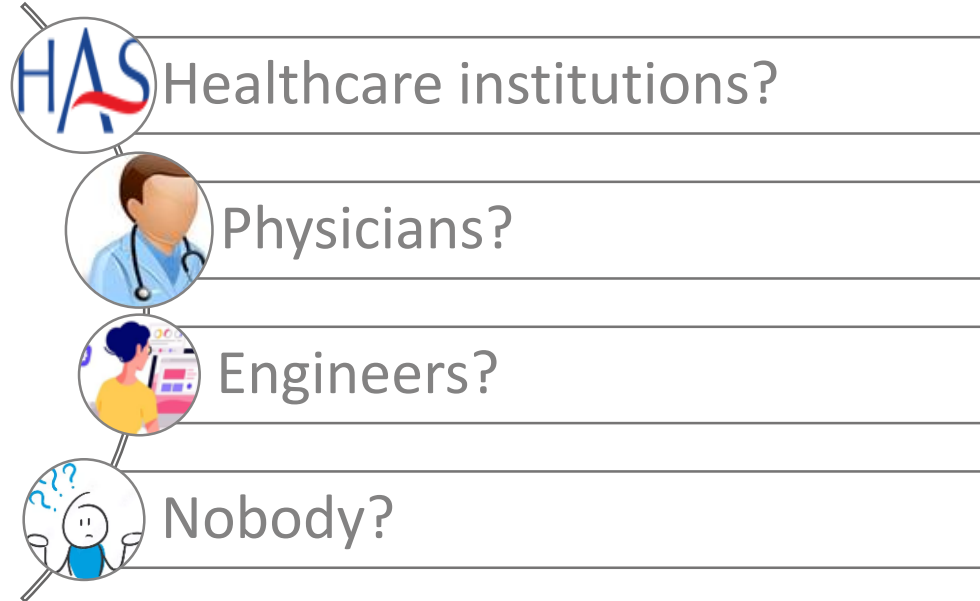
1. [Zuiderveen Borgesius \(2018\) – Discrimination, artificial intelligence, and algorithmic decision-making](#)
2. [Tsai, Fridsma and Gatti \(2003\) - Computer decision support as a source of interpretation error: the case of electrocardiograms](#)
3. [Povyakalo \*et al.\* \(2013\) – How to discriminate between Computer-Aided and Computer-Hindered Decisions: A Case study in Mammography](#)
4. [Bertillot \(2016\) – Comment l'évaluation de la qualité transforme l'hôpital. Les deux visages de la rationalisation par les indicateurs](#)



# RESPONSIBILITY ISSUES

## WHO IS TO BLAME?

If a physician uses an AI-based HIS, and this use conduct to medical error, who is responsible?



There is social pressure on physicians who use AI-based HIS <sup>1</sup>



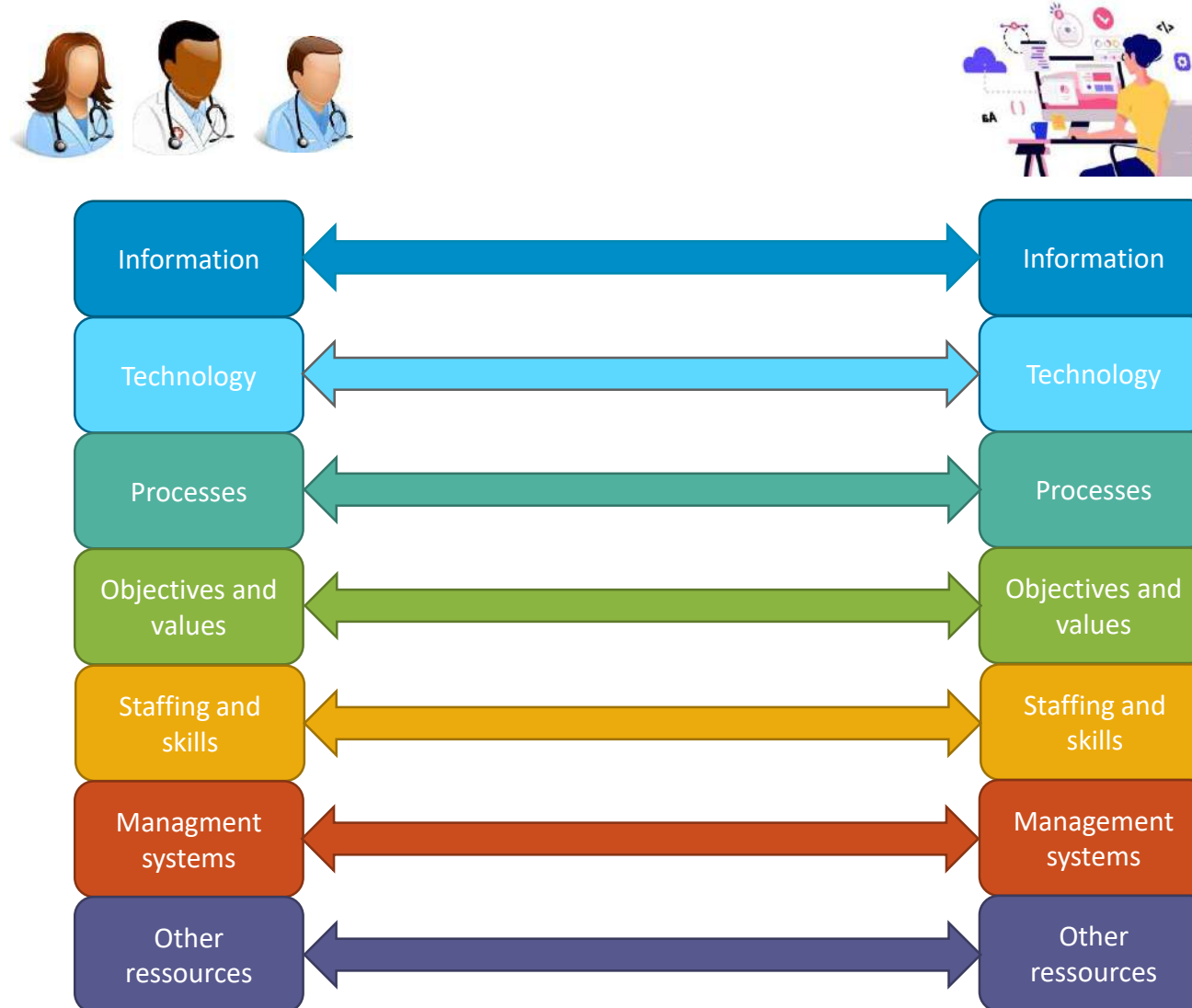
Legally, healthcare institutions are taken responsible in case of error and there are standards must be respected by engineers<sup>2 3</sup>

1. [Itani, Lecron and Fortemps \(2019\) – Specifics of medical data mining for diagnosis aid: A survey](#)
2. [ISO 13485:2016 – Medical devices — Quality management systems — Requirements for regulatory purposes](#)
3. [ISO 62304:2006 – Medical device software — Software life cycle processes](#)

# MAIN RISKS OF FAILURE

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## REALITY-DESIGN GAPS <sup>1 2</sup>



1. [Heeks \(2006\) – Health Information Systems:: Failure, success and improvisation](#)
2. [Masiero \(2016\) – The Origins of Failure: Seeking the Causes of Design-Reality Gaps](#)

# HOW TO DESIGN A AI-BASED HIS

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## A CONTINUOUS INTEGRATION PROCESS <sup>1</sup>

1. Identify and prioritize a problem
2. Identify requirements for an AI product as a viable component of the solution
3. Develop measures of outcomes and success of the AI product
4. Design a new optimal workflow to facilitate integration
5. Evaluate safety, effectiveness, and equity concerns of the AI product in the intended setting prior to clinical use
6. Execute AI product rollout, workflow integration, communication, education, and scaling
7. After operationalization, monitor and maintain the AI product and impacted ecosystem
8. Update or decommission the AI product and impacted ecosystem

1. [Kim et al. \(2023\) – Organizational Governance of Emerging Technologies: AI Adoption in Healthcare](#)

## SOME PRINCIPLES <sup>1 2 3</sup>

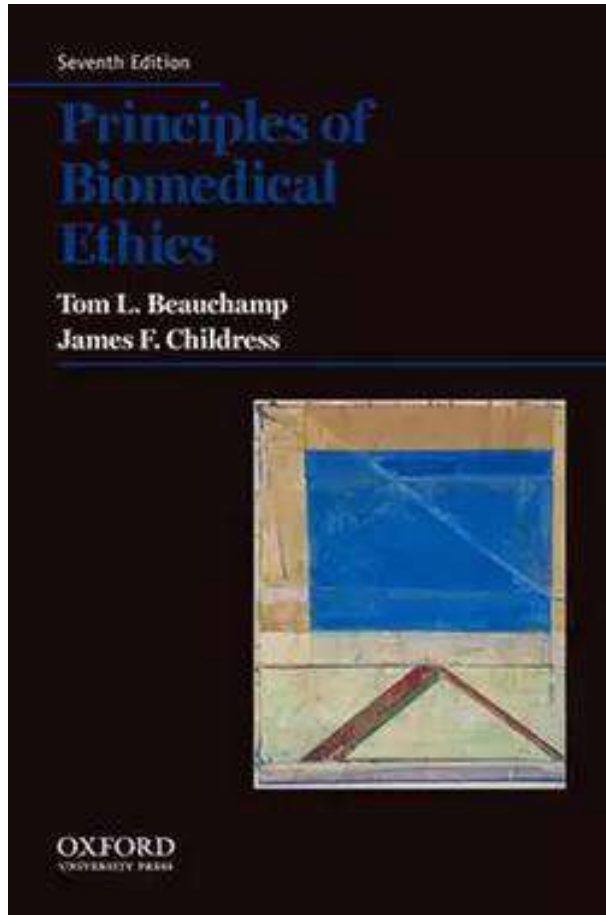


Le Serment  
Holberton-turing <sup>3</sup>

- Loyalty Principle
- Vigilance/Reflexivity Principle
- Autonomy Principle
- Justice Principle
- Transparency Principle

1. <https://www.cnil.fr/en/algorithms-and-artificial-intelligence-cnils-report-ethical-issues>  
2. <https://www.cnil.fr/en/ai-systems-compliance-other-guides-tools-and-best-practices>  
3. <https://www.holbertonturingoath.org/>

## A LARGE LITTERATURE <sup>1 2 3 4 5</sup>



- Non-maleficence Principle
- Beneficence Principle
- Autonomy Principle
- Justice Principle

1. [Miles \(2004\) – The Hippocratic Oath and the Ethics of Medicine](#)
2. [Beauchamp and Childress \(2013\) – Principles of Biomedical Ethics](#)
3. [Cook \(2020\) – Introduction to Biomedical Ethics](#)
4. [Ferretti \*et al.\* \(2020\) - Big Data, Biomedical Research, and Ethics Review: New Challenges for IRBs](#)
5. [Gomez-Virseda, Maeseneer and Gastmans \(2019\) - Relational autonomy: what does it mean and how is it used in end-of-life care? A systematic review of argument-based ethics literature](#)

## HOW MUCH CAN WE TRUST AI? <sup>1 2 3 4</sup>



- Why this result and not another one?
- How much can I trust this AI and its results?
- In which situation this AI is good or not?
- How to correct AI in case of error?

### Understandability

AI should be based on notions known by physicians

### Interpretability

Physicians must have all the information to interpret AI's results without bias

### Traceability

We must be able to trace back the context and the actions which conducted to a result

### Revisability

We must be able to take into account physicians' feedbacks

1. [Gunning and Aha \(2019\) – DARPA's Explainable Artificial Intelligence \(XAI\) Program](#)
2. [Berredo-Arrieta et al. \(2020\) - Explainable Artificial Intelligence \(XAI\): Concepts, taxonomies, opportunities and challenges toward responsible AI](#)
3. [Mueller et al. \(2019\) - Explanation in Humain-AI Systems: A Literature Meta-Review, Synopsis of Key Ideas and Publications, and Bibliography for Explainable AI](#)
4. [Richard et al. \(2020\) – Transparency of Classification Systems for Clinical Decision Support](#)

# PRACTICAL WORKS

DESIGNING AN AI-BASED HIS

## USE CASE: PATIENT TRIAGE IN EMERGENCY SERVICES

- **Your role:** engineers of health information systems
- **Your goal:** designing an AI-based HIS for emergency departments to simplify/automatize patient triage
- **At your disposal:** a dataset and a notebook

<https://github.com/a-t-richard/AI-Responsibility-in-Healthcare>



# MERCI

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