ALGORITHMS IN HEALTHCARE CONTEXTS

ETHICS AND RESPONSIBLITIES
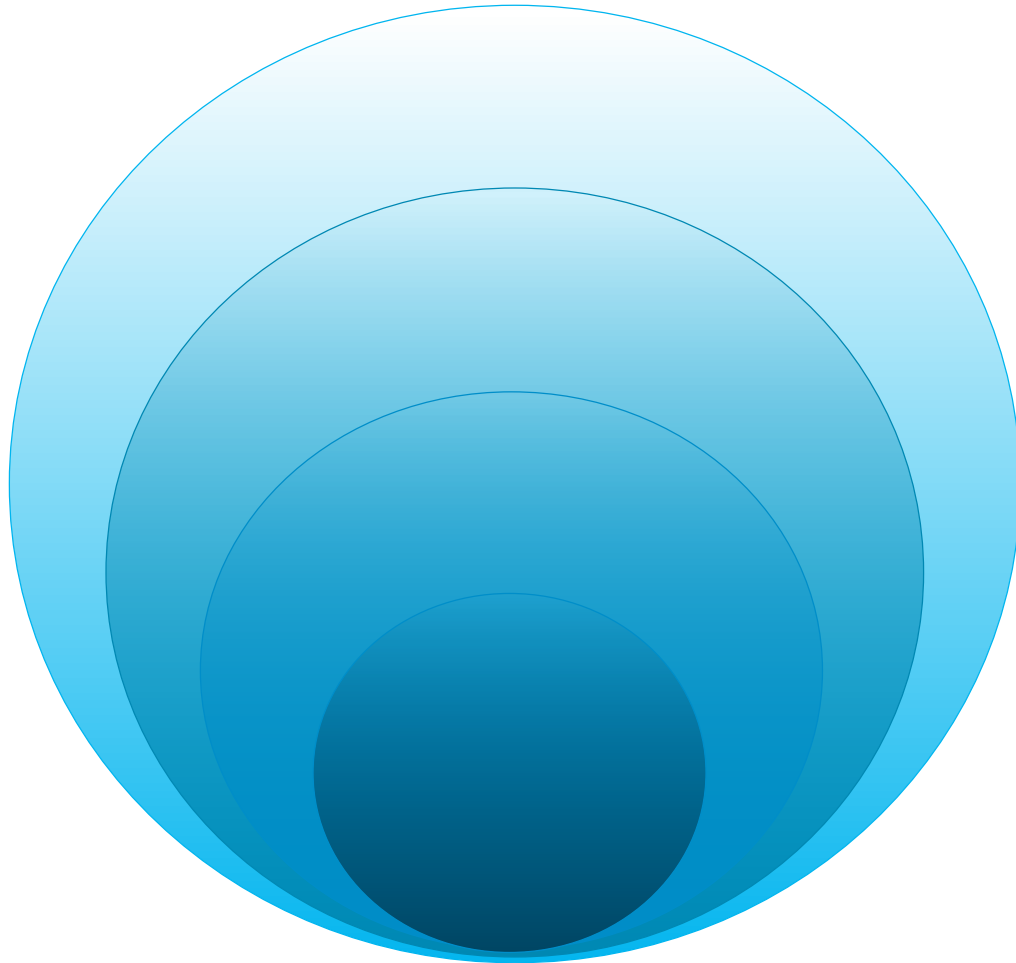
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DEFINITIONS

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[1]

Machine Learning:

Sub-domain of artificial intelligence dedicated to create algorithms able to learn from data how to perform a task[2]
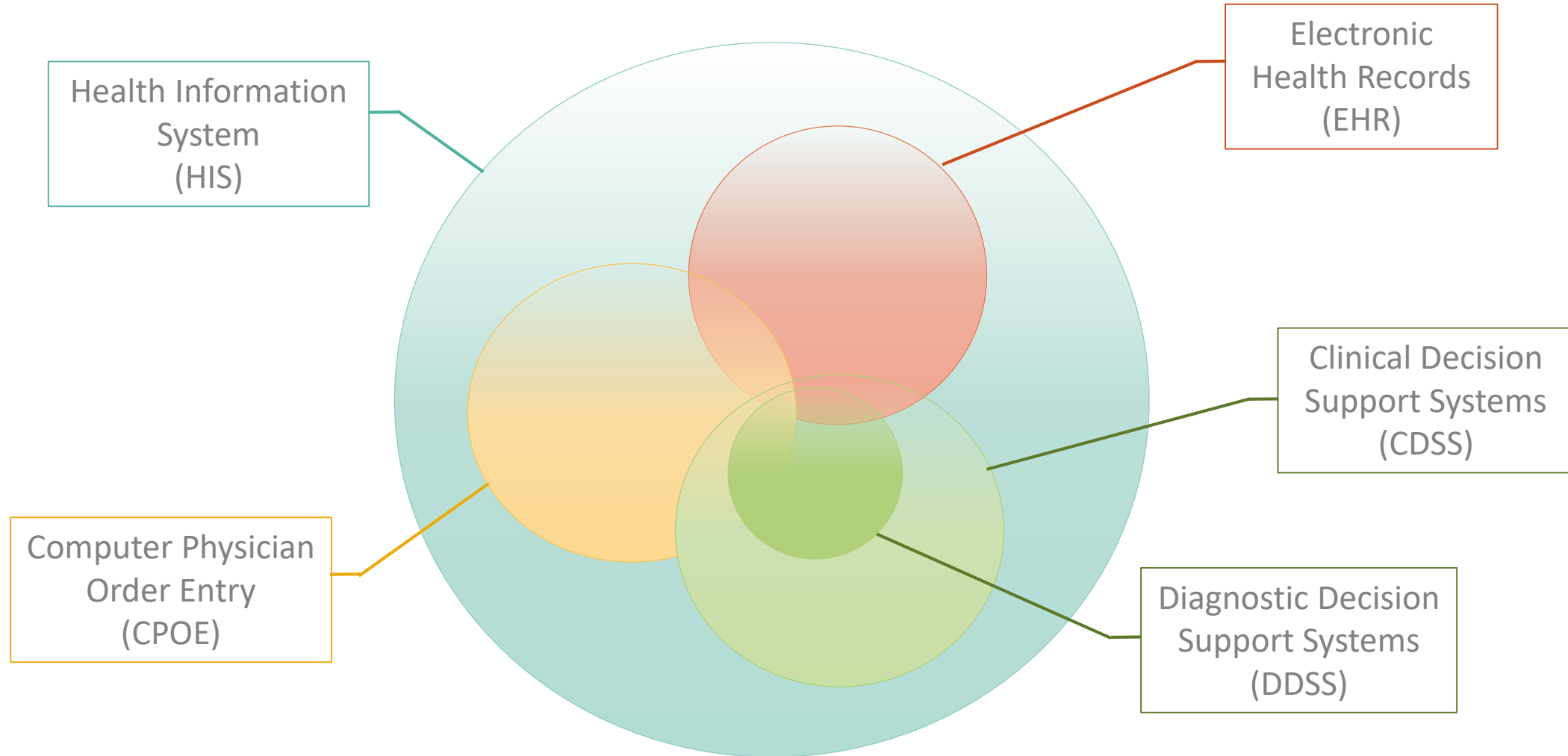
Deep Learning:

Sub-domain of machine learning dedicated to multi-layer artificial neural networks[3]

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 [1]

Health Information System (HIS)

Electronic Health Records (EHR)

Clinical Decision Support Systems (CDSS)

Computer Physician Order Entry (CPOE)
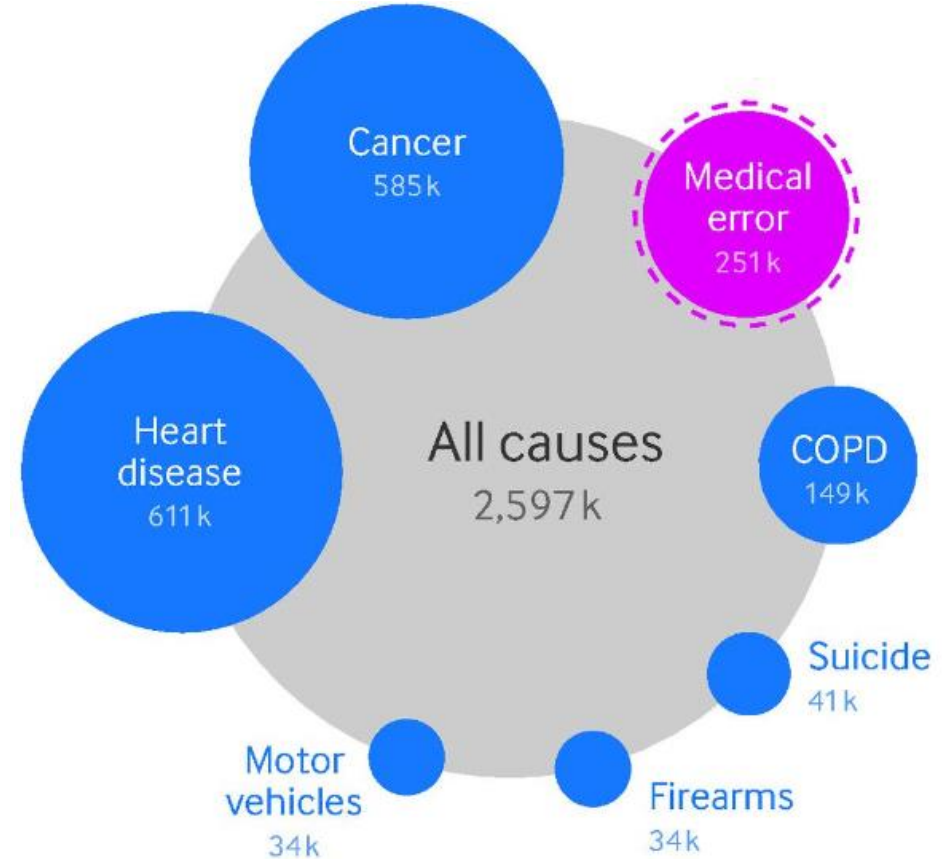
Diagnostic Decision Support Systems (DDSS)

1. Richard (2021) - Proposition d'un outil d'aide à la décision adapté aux contraintes et aux enjeux d'un soutien informatique aux consultations médicales coutumières

WHY DEVELOPING HIS?

TACKLE MEDICAL ERRORS
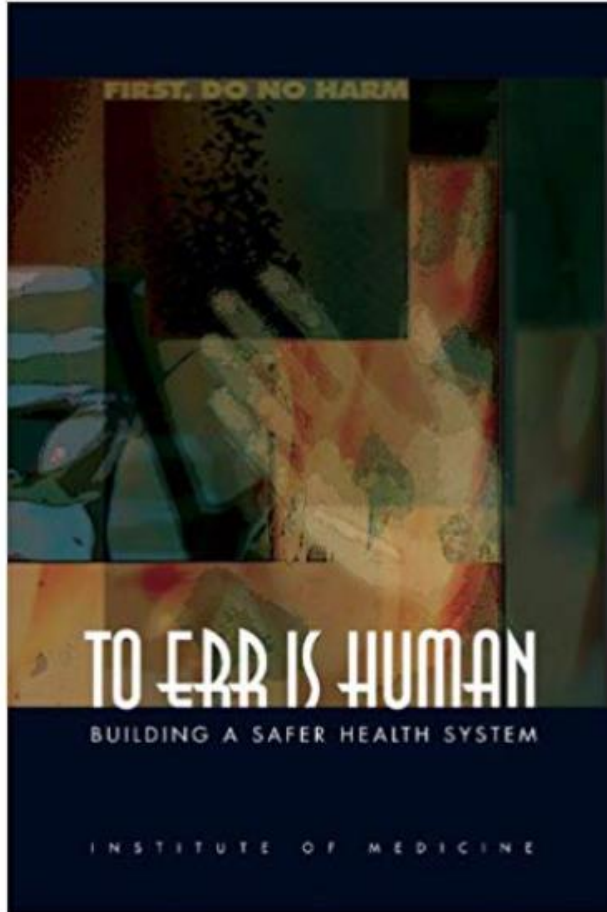
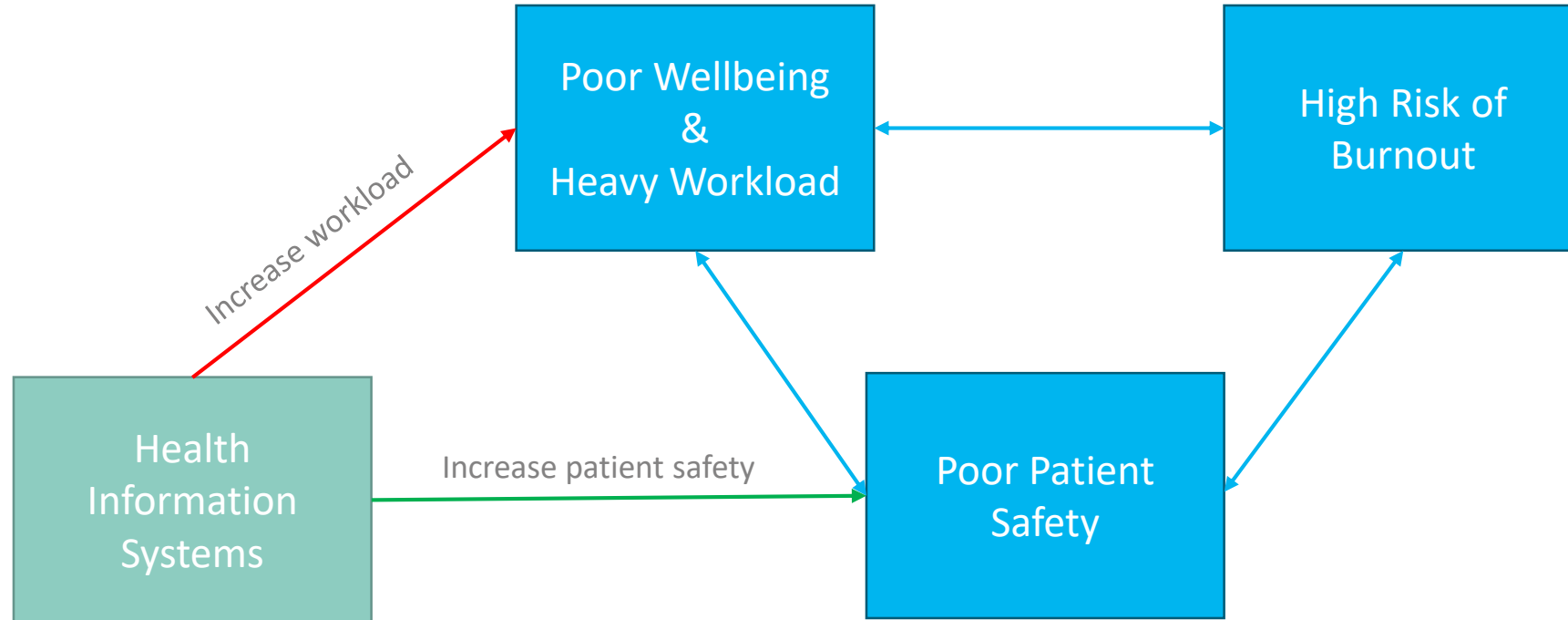Between 44k and 98k death in the US in 1997 [1]

The third cause of death in the US in 2013 [2]

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 [1] [2] [3] [4]

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
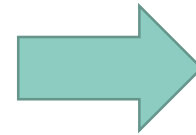
LEGAL FRAMEWORK

ISO STANDARDS

ISO 13485:
Quality management systems & Requirements for regulatory purposes
https://www.iso.org/standard/59752.html

ISO 62304:
Medical device software & Software life cycle processes

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

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
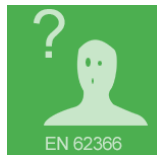
Applicable to AI ? [1] [2] [3]

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)

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

A SECOND WAVE OF COMPUTERIZATION

RISKS AND IMPACTS
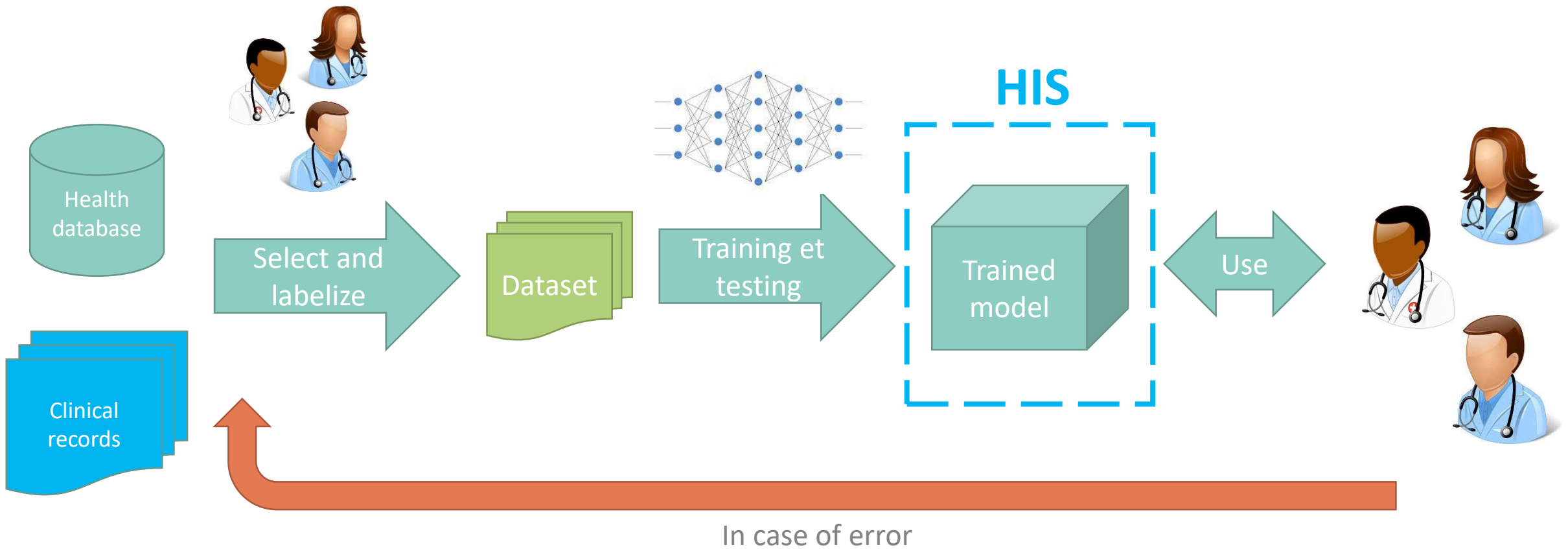
IN SHORT, MEDIUM AND LONG TERMS

Reproduction of discriminative behaviors [1]

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

Loss of physicians' skills and know-how [2] [3]

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 [4]

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?

Healthcare institutions?

Physicians?

Engineers?

Nobody?
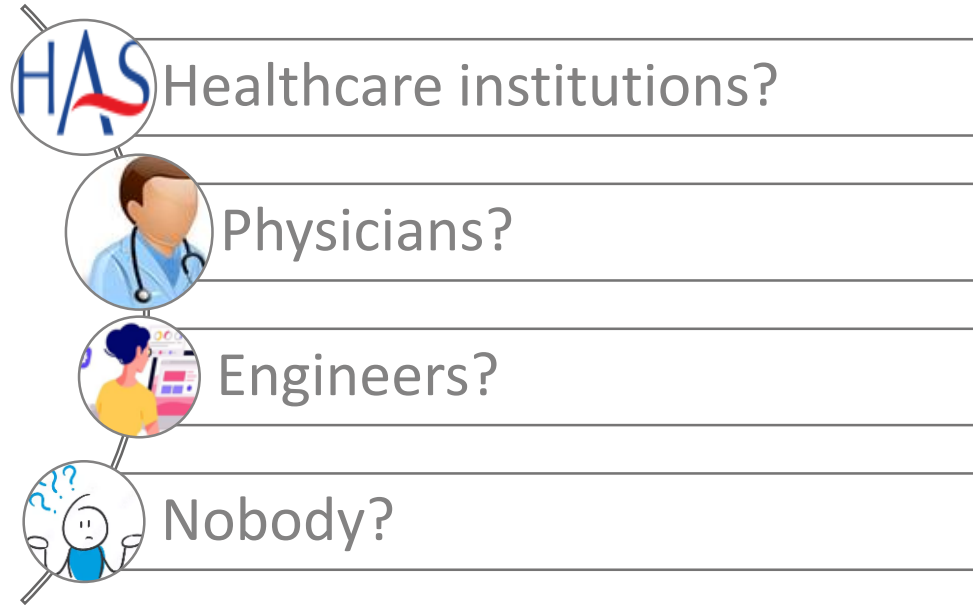
There is social pressure on physicians who use AI-based HIS [1]

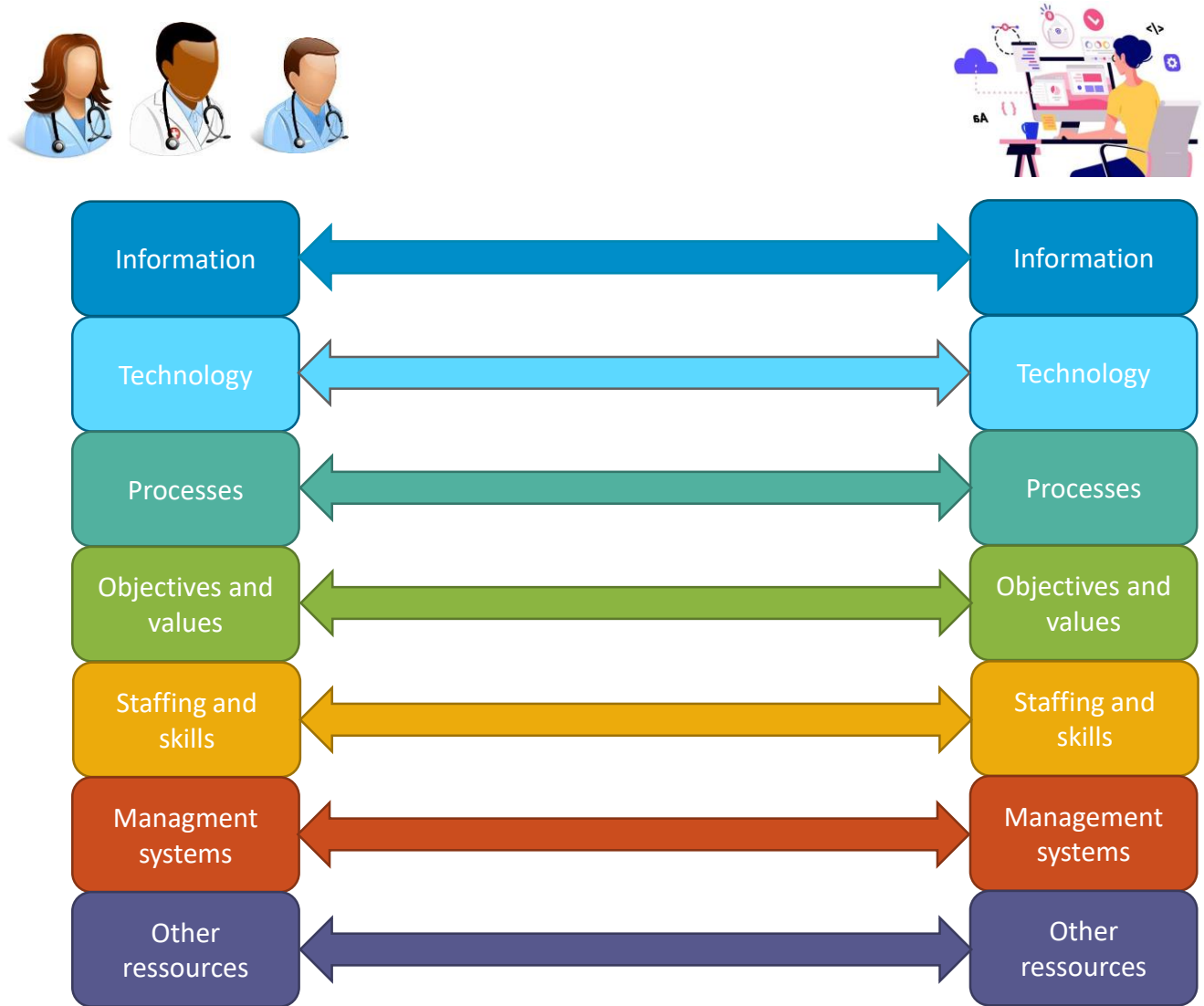Legally, healthcare institutions are taken responsible in case of error and there are standards must be respected by engineers [2,3]

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

REALITY-DESIGN GAPS [1] [2]

Information	Information
Technology	Technology
Processes	Processes
Objectives and values	Objectives and values
Staffing and skills	Staffing and skills
Managment systems	Management systems
Other ressources	Other ressources

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

A CONTINUOUS INTEGRATION PROCESS [1]

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

ETHICS OF ALGORITHMS

SOME PRINCIPLES [1] [2] [3]
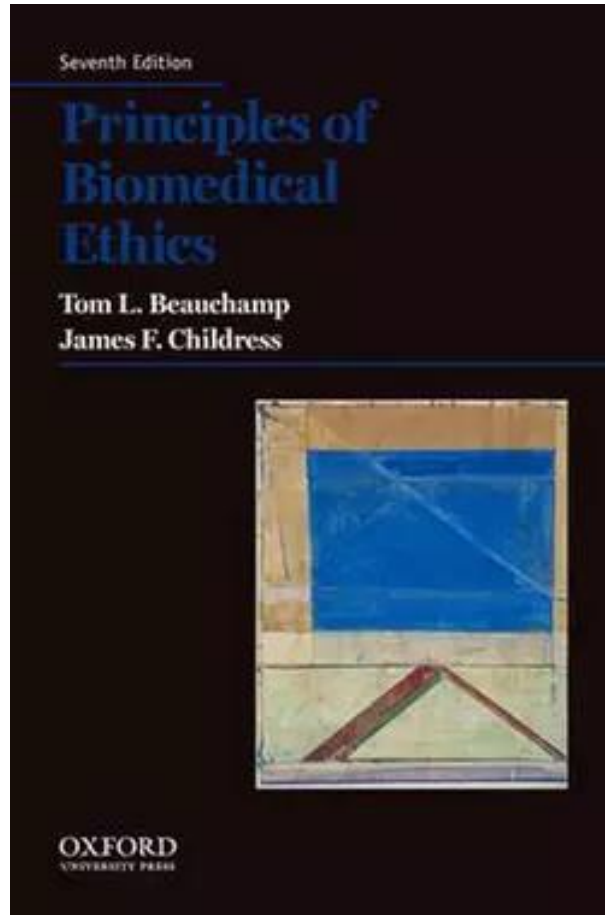
Le Serment
Holberton-turing [3]

- **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/

BIOMEDICAL ETHICS

A LARGE LITTERATURE [1] [2] [3] [4] [5]

- **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

TRANSPARENCY / EXPLICABILITY

HOW MUCH CAN WE TRUST AI? [1] [2] [3] [4]

- 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

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PRACTICAL WORKS

DESIGNING AN AI-BASED HIS

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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