Bracing for impact:

on-going digitalization of healthcare requires urgent characterization of impact on environment and beyond

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Introduction:
digital healthcare in France
Digital healthcare is on a roll in France
What is digital healthcare: a few examples

telemedecine

connected devices:
(e.g., blood glucose sensors)

Clinical Data Warehouses

medical decision support systems

Data extraction from clinical reports
A lot of expected benefits, diverse impact

**Expected benefits**
- Improved public health
- Improved Clinician work conditions
- Improved Patient autonomy
- Reduced operating costs

**Impacts**
- Environmental impacts:
  - e.g., digital equipment life cycle impacts
  - substitution effects? e.g., replacing paper
- Changes in healthcare system operations
Undone assessments of the impacts
Confidence in the benefits of digitalization

• "The professional services package will allow them to gain time and easily access a maximum of existing services" [Délégation ministérielle au Numérique en Santé, 2023]
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- "Thus, limiting the environmental impact of ICT in healthcare by limiting its uses is not a conceivable solution because it would lead to **reduce its benefits**" [Délégation Ministérielle au numérique en Santé, 2021]
The concrete effects of the digitalisation of healthcare are not properly assessed

**A number of factors impede assessment of impact**

- Digitalization at full speed of the healthcare
- Confidence in the benefits of digitalization
- A huge number of new solutions being created

Similarities with the controversy on regulating chlorinated chemicals studied in [Frickel et al., 2010].
The “chlorine sunset” controversy [Frickel et al., 2010]

- Extensive chemical manufacturing and contamination in the Great Lakes region
- Scientifically documented threats to wildlife and humans from persistent, toxic, industrial chlorinated pollutants
- Extensive citizen activism around this threat
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Risk VS. Precaution regulation paradigm

- North American legislation operated in a "risk paradigm": prohibiting only the individual chlorinated chemicals proven to be harmful.
- Civil society advocated for a "precaution-based paradigm", taking action against the whole class of chlorinated chemicals because of the properties they share with the known dangerous chlorinated chemicals.
French digital health regulation instances are operating in a "risk paradigm"

"Legal regulation is the basis of our society but, facing the rapid evolution of possibilities, auto-discipline [...] is a prerequisite for system operation"

[Délégation Ministérielle au numérique en Santé, 2023a]

the role of impacts research is thus ad-hoc identification of digital applications that are harmful.

We call for a "precaution-based paradigm"

a priori identification of safe and essential digital solutions.
Some regulation and ethics initiatives do exist

- EU 2017/745 (19) regulation: some digital solutions are medical devices → clinical trial before deployment

- Some initiatives exist on the ethics and impacts prevention/mitigation of digital solutions for healthcare [Délégation Ministérielle au numérique en Santé, 2021]

- Ethics of AI solutions for healthcare
  [Délégation Ministérielle au numérique en Santé, 2023b, CCNE and CNPEN, 2022]

- European chart of ethics principles for digital health [European Union, 2022]
Limitations of these initiatives

Digitalization in itself is seen as unquestionable

"Convinced by the necessary speedup in the deployment of ICT in healthcare"
[Agence du Numérique en Santé and Ministère de la Santé et de la Prévention, 2023]

- broad principles with no enforcement possibilities
- adding ethics over the digitalization at an individual level

Necessity of also questioning *what* to digitalize, or even if there should be a digitalization.
Similar criticism as devised by Green on Tech Ethics [Green, 2021].
Unraveling the impact of digitalization of healthcare
How to approach these transformations?

Need to pause and reflect before undergoing even more digitalization

- Evaluating the social consequences and environmental costs
- Presentation of rigorous arguments to political deciders for effectively performing the risks/benefits balance so crucial to the medical decision process in general
- Whose benefits?
A tentative framework to understand the impacts of digitalizing healthcare

Inspired by [Hilty and Aebischer, 2015] and [Kaack et al., 2021]

Environmental impacts

1. Direct effects
2. Effects of use
3. Systemic effects
A tentative framework to understand the impacts of digitalizing healthcare I

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Environmental impacts
1. Direct effects
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Social impacts (Local)
1. Direct effects
2. Structural effects
3. Systemic effects
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Public health impact
- Political definition of the impacts on public health
Environmental impacts

1. Direct effects: Life-cycle impacts of ICT equipment in healthcare (Hardware manufacturing, software and data storage...)
2. Effects of use: substitution and induction effects
3. Systemic effects: rebound effects
A tentative framework to understand the impacts of digitalizing healthcare II

Environmental impacts

1. Direct effects: Life-cycle impacts of ICT equipment in healthcare (Hardware manufacturing, software and data storage...)
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Social impacts (Local)

1. Direct effects: Changes to the work of clinicians/patients follow-up
2. Structural effects: changes in clinician/patient relationships and in healthcare organisation
3. Systemic effects: loss of skills, digital dependency...

[Besnier et al., 2022]
A tentative framework to understand the impacts of digitalizing healthcare II

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[Besnier et al., 2022]

Public health impact

- Political definition of the impacts on public health
- Whose health (French / Worldwide?, Rich/Poor?, Urban/Rural? ...)
- at what temporal horizon?
Our study

Focus on the digitalization enabling Natural Language Processing (NLP) research and use in healthcare

- development of Clinical Data Warehouses (CDW) in France [Jannot et al., 2017, Haute Autorité de Santé, H.A.S., 2022]
- rendering health information readily available for digital processing.
- Textual data are increasingly in demand for processing to exploit information that exists only in this form [Escudié et al., 2017]

Environmental impacts

1. Direct effects: A tool for Machine Learning life Cycle Assessment
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qualitative pre-survey
Assessing the environmental impacts of AI in healthcare
### Tools for the evaluation of the environmental impacts of computation

<table>
<thead>
<tr>
<th>Outil</th>
<th>Life cycle phase considered</th>
<th>Multiple impacts considered</th>
<th>Estimates consumption</th>
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Evaluated impacts:
- Abiotic resources Depletion Potential (ADP), measured in kgSbeq [van Oers et al., 2020, Bruijn et al., 2002]
- Primary Energy (PE), measured in MJ [Frischknecht et al., 2015]
- Global Warming Potential (GWP), measured in gCO₂eq [Forster et al., 2023]
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- GWP, measured in gCO₂eq [Forster et al., 2023]
A tool for Machine Learning life Cycle Assessment (MLCA)

<table>
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<tr>
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Production impacts
Modeling graphics cards

Production impacts attribution

Usage impacts
Infrastructure consumption

Putting impacts in perspective with global sustainability targets
Putting impacts in perspective

Need for a global perspective [Rasoldier et al., 2022], [Hauschild, 2015]

"Stratégie Nationale Bas Carbone" \(^a\)
2 tCO\(_2\) eq/person/year

\(^a\)https://indicateurs-snbc.developpement-durable.gouv.fr/

Planetary boundaries [Sala et al., 2020]

- PB\(_{GWP}\) = 985 kgCO\(_2\) eq/person/year
- PB\(_{ADP}\) = 3.17E-02 kgSb eq/person/year

\(^a\)Credit: "Azote for Stockholm Resilience Centre, based on analysis in Persson et al 2022 and Steffen et al 2015"
Putting impacts in perspective

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http://calculator.green-algorithms.org/
Putting impacts in perspective

Need for a global perspective [Rasoldier et al., 2022], [Hauschild, 2015]

**GWP:** 59 tCO$_2$ eq
- annual emissions of 59 person (PB$_{GWP}$)
- annual emissions of 29 person (SNBC)

**ADP:** 1.2 kgSb eq
- annual resource extraction of 38 person (PB$_{ADP}$)

**PE:** 9800000 MJ

http://calculator.green-algorithms.org/
Exploring the social impacts of AI in healthcare
Interviews for understanding the current state of ICT in French healthcare

Objectives

- Overview of ICT in healthcare, the needed infrastructures and probable evolution
- Understanding the state of reflection of the professionals on the sustainability of ICT in healthcare

Focused on AI use in clinical data warehouses (Entrepôts de Données de Santé (EDS))

Protocol

- Series of semi-structured interviews [DiCicco-Bloom and Crabtree, 2006]
- 9 persons contacted, 7 positive responses, one decline and one pending.
Presentation and description of the objectives of the interview then:

1. What is your job and background?
2. What are the digital tools you use in your work or know are being used in health?
3. What infrastructure exists or is needed to support this/these usages?
4. What is the reflection on the environmental impacts induced by this/these usages?
5. What is the reflection on the ethics of using the Information and Communication Technologies (ICT) in health?
### Participants of the study

<table>
<thead>
<tr>
<th>Name</th>
<th>Background</th>
<th>Hospital staff</th>
<th>NLP researcher</th>
<th>Governmental agency staff</th>
<th>Management of an EDS</th>
<th>City</th>
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<td>Christel Gerardin</td>
<td>CS &amp; MD</td>
<td>✓</td>
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<td>Antoine Neuraz</td>
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<td>Stéfan Darmoni</td>
<td>CS &amp; MD</td>
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<td>Rouen</td>
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<td>Brigite Seroussi</td>
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**CS** = Computer Science, **MD** = Medical Doctor
**MBA** = Engineer and Management
**Usages**

- Development of the Clinical Data Warehouses (CDW)
- CDW for research, care and direction
- Mostly new tools for automation

**Infrastructure**

- System duplication
- Computing power
- A turning point in infrastructure development
Interviews summary, Environmental policies

Environmental policies

- Little to no policies known by the researchers
- Carbon footprint of IT systems: > 5% of the carbon footprint of an average university hospital [Délégation Ministérielle au numérique en Santé,, 2021]
- Existing policies: eco-score

Ethics

- Importance of privacy
- Rupture of the patient-clinician relationship
- Question of responsibility
- Question of medical training
- Risks of cyber-attacks and digital dependency
1. ICT are ubiquitous within French healthcare (healthcare organisation, clinical practice, public health research).
2. The new availability of clinical data warehouses places the system at a turning point towards new deployment/uses of ICT in healthcare.
3. Still the beginning of the reflection on the sustainability of the ICT in health.
Discussion/conclusion
Conclusion

- A turning point in the development of digital healthcare
- Necessity of evaluating the environmental and social sustainability of digitalizing healthcare
- Bringing arguments to the political discussion of the definitions of costs/risks and benefits in this context
- Application level assessment but necessity of large scale questioning


Délégation ministérielle au Numérique en Santé (2023).  
**Feuille de route du numérique en santé 2023-2027.**  
accessed on October 2 2023 at https://esante.gouv.fr/sites/default/files/media_entity/documents/dns-feuille-de-route-2023-2027.pdf.

Délégation Ministérielle au numérique en Santé (2023a).  
**Rapport d’impact: Campagne de communication "pour ma santé, je dis oui au numérique !".**  


A novel data-driven workflow combining literature and electronic health records to estimate comorbidities burden for a specific disease: a case study on autoimmune comorbidities in patients with celiac disease.

*BMC Medical Informatics and Decision Making*, 17.

European Union (2022).

European ethical principles for digital health.


How realistic are claims about the benefits of using digital technologies for ghg emissions mitigation?
LIMITS’22: Workshop on Computing within Limits.

Environmental sustainability of european production and consumption assessed against planetary boundaries.

Abiotic resource depletion potentials (ADPs) for elements revisited—updating ultimate reserve estimates and introducing time series for production data.