Bracing for impact:

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

Clément Morand & Anne-Laure Ligozat & Aurélie Névéol

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Laboratoire Interdisciplinaire des Sciences du Numérique

Introduction: digital healthcare in France

Digital healthcare is on a roll in France

POUR MA SANTÉ
JE DIS OUI
AU NUMÉRIQUE

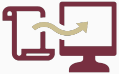
What is digital healthcare: a few examples

telemedecine

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

medical decision
support systems

Clinical Data
Warehouses



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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- "The rapid development of ICT usage in healthcare is an **important factor** for the improvement of healthcare quality" [Agence du Numérique en Santé and Ministère de la Santé et de la Prévention, 2023]
- "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]

Undone assessment of impact

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.

Advocating for a precaution based paradigm for ICT in healthcare

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 I

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

Environmental impacts

1. Direct effects
2. Effects of use
3. Systemic effects

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$\Downarrow$

Public health impact

- Political definition of the impacts on public health

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. . .)
2. Effects of use: substitution and induction effects
3. Systemic effects: rebound effects

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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]

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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 Wharehouses* (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]

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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

Outil	Life cycle phase considered						Multiple impacts considered	Estimates consumption	GPU support
	Ext.	Man.	Tra.	Uti.		EoL.			
				Infra.	Dyn.				
Green Algorithms	✗	✗	✗	✓	✓	✗	✗	✓	✓
ML CO_2 Impact	✗	✗	✗	✗	✓	✗	✗	✓	✓
CarbonTracker	✗	✗	✗	✓	✓	✗	✗	✗	✓
CodeCarbon	✗	✗	✗	✓	✓	✗	✗	✗	✓
Boavizta	✓	✓	✗	✗	✗	✗	✓	-	✗

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CarbonTracker	✗	✗	✗	✓	✓	✗	✗	✗	✓
CodeCarbon	✗	✗	✗	✓	✓	✗	✗	✗	✓
Boavizta	✓	✓	✗	✗	✗	✗	✓	-	✗

Evaluated impacts

- ADP, measured in kgSbeq [van Oers et al., 2020, Bruijn et al., 2002]
- PE, measured in MJ [Frischknecht et al., 2015]
- GWP, measured in gCO_2eq [Forster et al., 2023]

A tool for Machine Learning life Cycle Assessment (MLCA)

	ADP	GWP	PE	Human toxicity	Water Consumption	...
Extraction	✓	✓	✓	✗	✗	✗
Manufacturing	✓	✓	✓	✗	✗	✗
Transport	✗	✗	✗	✗	✗	✗
Usage	✓	✓	✓	✗	✗	✗
End of Life	✗	✗	✗	✗	✗	✗

Production impacts
Modeling graphics cards

Production impacts attribution

Usage impacts
Infrastructure consumption

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

Putting impacts in perspective with global sustainability targets

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

COP21 · CMP11
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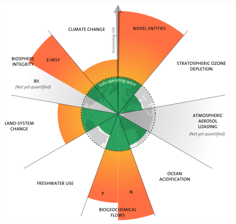
"Stratégie Nationale Bas Carbone" [a]

2 tCO_2 eq/person/year

[a] https://indicateurs-snbc.developpement-durable.gouv.fr/



[a]

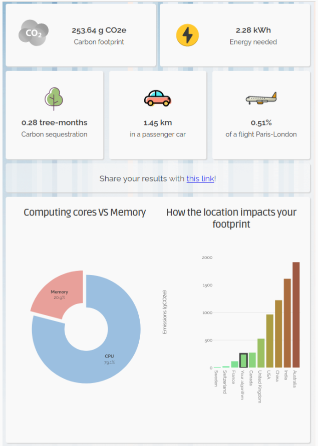
Planetary boundaries [Sala et al., 2020]

- PB_{GWP} = 985 $kgCO_2$ eq/person/year
- PB_{ADP} = 3.17E-02 kgSb eq/person/year

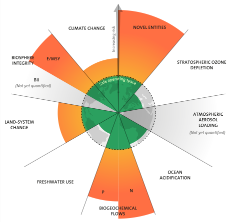
[a] Credit: "Azote for Stockholm Resilience Centre, based on analysis in Persson et al 2022 and Steffen et al 2015"

Putting impacts in perspective

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



http://calculator.green-algorithms.org/



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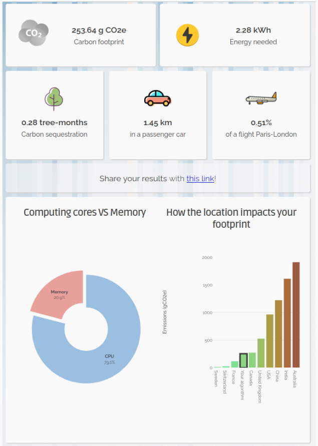

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training the BLOOM model

- GWP: $59tCO_2$ 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

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 reflexion 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.

Interview protocol

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 Techonlogies (ICT) in health?

Participants of the study

Name	Background	Hospital staff	NLP researcher	Governmental agency staff	Management of an EDS	City
Christel Gerardin	CS & MD	✓	✓	✗	✗	Paris
Antoine Neuraz	CS & MD	✓	✓	✗	✗	Paris
Bastien Rance	CS	✓	✓	✗	✗	Paris
Romain Bey	CS	✓	✓	✗	✓	Paris
Stéfan Darmoni	CS & MD	✓	✓	✗	✓	Rouen
Nathalie Baudinière	MBA	✗	✗	✓	✗	Paris
Brigite Seroussi	CS & MD	✓	✓	✓	✗	Paris

CS = Computer Science, MD = Medical Doctor

MBA = Engineer and Management

Interviews summary, Usages & Infrastructure

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

Overview of ICT in healthcare, conclusions

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

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