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

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Medical research and practice are undergoing a surge in the use of digital technology. There is a political will for accelerating digitalization in France with a regularly updated roadmap for *Information and Communication Technologies* (ICT) in healthcare [5], accompanied by the publication of an ICT in healthcare doctrine [1].

However, with these increased usages also come increasing impacts (environmental but not only). The global carbon footprint of the ICT sector is continuously rising [19, 10, 13, 3]. A governmental report [9] has estimated that more than 5% of the total carbon footprint of an average French University Hospital is due to ICT. Furthermore, this report also estimates the total carbon footprint of the IT systems of all French hospitals at 190,000 tCO_2e in 2018.

Healthcare roadmaps and reports (implicitly) justify the increased ICT environmental impacts by the expected benefits of digitalization: "This report chose to believe in a positive promise for ICT in healthcare"[1] [15]; "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"[2] [9]; "Convinced by the soundness of AI implementation in healthcare and of the necessary promotion of innovation in the benefit of healthcare"[3] [8]; "The professional services package will allow them to gain time and easily access a maximum of existing services"[4] [5]; "The rapid development of ICT usage in healthcare is an important factor for the improvement of healthcare quality"[5] [1] .

The digitalization at full speed of the healthcare sector prevents any rigorous study of impacts from being conducted to properly evaluate the potential of such a drastic change in how the healthcare system works. This situation may recall the controversy on regulating chlorinated chemicals studied in [11]. Indeed, North American legislation operated in a "risk paradigm", prohibiting only the individual chlorinated chemicals proven to be harmful. On the opposite side, civil society asked 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. Similarly, French digital health regulation instances are operating in a "risk paradigm"[6] where the role of impacts research is *ad-hoc* identification of digital applications that are harmful: "Legal regulation is the basis of our society but, facing the rapid evolution of possibilities, auto-

[1] *Ce rapport a choisi de croire à une promesse positive dans le numérique en santé.* in the text p107

[2] *Ainsi, limiter l'impact environnemental du numérique en santé en limitant les usages n'est pas une option envisageable car cela conduirait à réduire les bénéfices* in the text p26

[3] *"Convaincus du bien-fondé de la mise en œuvre de l'IA dans le domaine de la santé et de la nécessaire promotion de l'innovation au bénéfice de la médecine"* in the text p7

[4] *"le Bouquet de services aux professionnels leur permettra de gagner du temps et d'accéder simplement à un maximum de services existants"* in the text p22

[5] *"Le développement rapide de l'usage du numérique en santé constitue un facteur important d'amélioration de la qualité des soins"* in the text p20

[6] It is to be noted that there exist some regulation initiatives to ensure health benefits, like the EU 2017/745 (19) regulation that qualifies some digital solutions as Medical device and therefore requires a clinical trial before deployment

discipline [...] is a prerequisite for system operation"[7] [7]. On the contrary, we call for a "precaution-based paradigm" with an *a priori* identification of safe and essential digital solutions.

Some initiatives exist on the ethics and impacts prevention/mitigation of digital solutions for healthcare [9] and particularly on the ethics of AI solutions for healthcare [8, 4]. A chart of ethics principles for digital health was created at the European level [20]. However, we can draw criticisms on these initiatives. The ethics principles adopted are broad and do not have any enforcement possibilities. Furthermore, they focus on adding ethics over the digitalization of healthcare and thus focus on *how* to build better technology rather than on *what* technology to build, or even if it should be built. Digitalization is seen as inevitable: "Convinced by the necessary speedup in the deployment of ICT in healthcare"[8] [1]. These criticisms are similar to the one devised by Green on Technology Ethics [12].

Therefore, we believe there is a need to pause and reflect, before undergoing even more digitalization, on evaluating the consequences and environmental costs. This process would allow the presentation of rigorous arguments to political deciders for effectively performing the risks/benefits balance so crucial to the medical decision process in general.

In this work, we propose a framework to characterise three different levels of environmental, social and societal impacts of ICT in health inspired by [16] and [18]. On the first level are the life cycle impacts of ICT equipment in healthcare (Hardware manufacturing, Software and data storage...). These impacts can be modelled and understood using a life cycle assessment method. On the second level are the impacts on the healthcare system (changes in organisation, changes in clinician/patient relationships, loss of skills...)[2]. Finally, on the third level are the final impacts on public health (Is the population on average healthier? How are the gains (and losses) in health distributed...)[9]. It is this level that really motivates political decisions.

We take first steps towards better understanding the impacts at the first two levels. We focus on the digitalization enabling *Natural Language Processing* (NLP) research and use in healthcare. In France, one particular example of undergoing digitalization is the development of *Clinical Data Wharehouses* (CDW) ([17, 14]) that make health information readily available for digital processing. Textual data are thus increasingly in demand for processing to exploit information that exists only in this form [6].

We approach the first level of impacts by developing a new tool aimed at AI researchers to estimate the potential impacts over the whole life-cycle of the hardware they mobilise, attributable to the experiments they are willing to make. This tool estimates multiple impact criteria, mainly *Global Warming Potential* (GWP) and *Abiotic Resource Depletion* (ADP) and presents them in perspective with different sustainability targets.

We explore the second level of impact through a series of semi-structured interviews to better understand the current state of NLP research and its use in healthcare, its expected evolution through CDW projects, the questions it poses and the current state of regulation. The main conclusions from these interviews are as follows: 1) ICT are ubiquitous within French healthcare (healthcare organisation, clinical practice, and 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) We are still at the beginning of the reflection on the sustainability of ICT in health.

References

[1] Agence du Numérique en Santé and Ministère de la Santé et de la Prévention. Doctrine du numérique en santé version 2022, February 2023. accessed on October 2 2023 at `https://esante.gouv.fr/sites/default/files/media_entity/documents/doctrine-du-numerique-en-sante_version-2022_vf.pdf`.

[2] Jean-Michel Besnier, Grégory Bonnet, Vincent Bunel, Jean-Marc Deltorn, Philippe Drweski, Hervé Dumez, Marie-Pia D'Ortho, Rodolphe Gouin, Camille Jean, Cristina Lindenmeyer,

[7] "la régulation par la loi est la base de notre société, mais devant l'évolution rapide des possibilités, l'autodiscipline [...] est un prérequis au fonctionnement du système" in the text second *edito*

[8] *"Convaincus de la nécessaire accélération du déploiement du numérique en santé"* in the text p29

[9] See for instance Valérie d'Acremont's conference accessible at `https://www.youtube.com/watch?v=oKcy_cY0QOw`

Étienne Minvielle, and Aloïse Quesne. *Santé connectée*. Les essentiels d'Hermès. CNRS Éditions, Paris, 2022.

[3] David Bol, Thibault Pirson, and Rémi Dekimpe. Moore's Law and ICT Innovation in the Anthropocene. In *2021 Design, Automation & Test in Europe Conference & Exhibition (DATE)*, pages 19–24, 2021.

[4] CCNE and CNPEN. Diagnostic Médical et Intelligence Artificielle : Enjeux Éthiques. Avis commun du CCNE et du CNPEN, Avis 141 du CCNE, Avis 4 du CNPEN., November 2022.

[5] Délégation ministérielle au Numérique en Santé. Feuille de route du numérique en santé 2023-2027, May 2023. accessed on October 2 2023 at `https://esante.gouv.fr/sites/default/files/media_entity/documents/dns-feuille-de-route-2023-2027.pdf`.

[6] Jean-Baptiste Escudié, Bastien Rance, Georgia Malamut, Sherine Khater, Anita Burgun, Christophe Cellier, and Anne-Sophie Jannot. 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, September 2017.

[7] Délégation Ministérielle au numérique en Santé, Cellule éthique : GT1 Sensibilisation du grand public à l'éthique du numérique en santé. Rapport d'impact: Campagne de communication "pour ma santé, je dis oui au numérique !", May 2023. accessed on October 10 2023 at `https://esante.gouv.fr/sites/default/files/media_entity/documents/210309_rapport-de-synthese_gt1-ethique_vf.pdf`.

[8] Délégation Ministérielle au numérique en Santé, Cellule éthique : GT3 Ethique by design. Recommandations de bonnes pratiques pour intégrer l'éthique dès le développement des solutions d'intelligence artificielle en santé : mise en œuvre de "l'éthique by design", May 2023. accessed on October 2 2023 at `https://esante.gouv.fr/sites/default/files/media_entity/documents/ethic_by_design_guide_vf.pdf`.

[9] Délégation Ministérielle au numérique en Santé, Cellule éthique : GT6 Numérique Responsable. L'impact environnemental du numérique en santé, May 2021. accessed on October 2 2023 at `https://esante.gouv.fr/sites/default/files/media_entity/documents/RAPPORT_GT6_VF.pdf`.

[10] Charlotte Freitag, Mike Berners-Lee, Kelly Widdicks, Bran Knowles, Gordon S Blair, and Adrian Friday. The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations. *Patterns*, 2(9):100340, 2021.

[11] Scott Frickel, Sahra Gibbon, Jeff Howard, Joanna Kempner, Gwen Ottinger, and David J. Hess. Undone science: Charting social movement and civil society challenges to research agenda setting. *Science, Technology, & Human Values*, 35(4):444–473, 2010. PMID: 32099268.

[12] Ben Green. The contestation of tech ethics: A sociotechnical approach to technology ethics in practice. *Journal of Social Computing*, 2(3):209–225, 2021.

[13] Udit Gupta, Young Geun Kim, Sylvia Lee, Jordan Tse, Hsien-Hsin S. Lee, Gu-Yeon Wei, David Brooks, and Carole-Jean Wu. Chasing carbon: The elusive environmental footprint of computing, 2022.

[14] Haute Autorité de Santé, H.A.S. Entrepôts de données de santé hospitaliers en france, 2022. accessed on October 2 2023 at `https://www.has-sante.fr/jcms/p_3386123/fr/entrepots-de-donnees-de-sante-hospitaliers-en-france`.

[15] Haute Autorité de Santé,H.A.S. Numérique : quelle (R)évolution ? rapport d'analyse prospective 2019, 2019.

[16] Lorenz M. Hilty and Bernard Aebischer. ICT for Sustainability: An Emerging Research Field. In Lorenz M. Hilty and Bernard Aebischer, editors, *ICT Innovations for Sustainability*, pages 3–36, Cham, 2015. Springer International Publishing.

[17] Anne-Sophie Jannot, Eric Zapletal, Paul Avillach, Marie-France Mamzer, Anita Burgun, and Patrice Degoulet. The Georges Pompidou University hospital clinical data warehouse: a 8-years follow-up experience. *International journal of medical informatics*, 102:21–28, 2017.

[18] Lynn H Kaack, Priya L Donti, Emma Strubell, George Kamiya, Felix Creutzig, and David Rolnick. Aligning artificial intelligence with climate change mitigation. An updated version is now published with Nature Climate Change and can be found as:Kaack, L.H., Donti, P.L., Strubell, E. et al. Aligning artificial intelligence with climate change mitigation. Nat. Clim. Chang. 12, 518–527 (2022). https://doi.org/10.1038/s41558-022-01377-7, October 2021.

[19] Jens Malmodin, Nina Lövehagen, Pernilla Bergmark, and Dag Lundén. ICT Sector Electricity Consumption and Greenhouse Gas Emissions – 2020 Outcome. *SSRN*, April 2023.

[20] European Union. European ethical principles for digital health, 2022. accessed on October 2 2023 at `https://sante.gouv.fr/IMG/pdf/220131_european_ethical_principles_for_digital_health_fr_eng.pdf`.