Towards the Operationalization of Sustainable Digital Health

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***Abstract*—The comprehensive appraisal of emerging technology in health remains theoretically challenging and difficult to implement in practice. Nevertheless, this work highlights the pragmatic approach that can be adopted to address the sustainability of technological innovation in the medical and health fields, while offering a structural and conceptual analysis of the fundamental purpose of "smart" technology in these domains as a starting point. This article aims to formulate two hypotheses for effectively addressing the integral Cost-Effectiveness Analysis of digital health and, based on this, to establish a principle upon which future research can be built.**

***Keywords*—Digital health, sustainability, Life Cycle Assessment, eco design, Health Technology Assessment, Cost-Effectiveness Analysis**

I. Introduction

Digital health brings substantial benefits to the healthcare and medical sectors, as evidenced in recent literature [1-3]. However, it can be also plagued with social and environmental vulnerabilities that may undermine the perceived gains [4-6]. According to the World Health Organization (WHO), digital health should promote both physical and psychological well-being, and it should be appropriate, accessible, affordable, scalable, and sustainable [7]. Yet, determining whether a digital-based solution aligns with all of these requirements without causing unintentional damage remains overlooked.

In the context of "smart" technologies, this evaluation process remains in its nascent stages, currently addressing clinical outcomes, ethical aspects, efficiency, and/or efficacy [8] separately. Moreover, it completely neglects environmental sustainability. To address this gap, we argue that the integral analysis of the global advantages and disadvantages of smart technologies in digital health should embrace a pragmatic approach, primary based on the sensing, sizing, and transforming capabilities [9] of smart medical devices and systems.

II. Hypothesis

Sensing, sizing and transforming are the primary functions of smart technology, all designed to provide information to humans and/or machines autonomously [10]. In the medical field, this suggests that *"smart devices continuously sense and collect data, thereby generating information that is subsequently analyzed and contextualized to implement medical treatments efficiently and effectively and allocate healthcare resources optimally"* **(hypothesis 1)**.

Meaningful information, on the other hand, can be assumed as *"the critical message from which a sustainable digital-based health service or paradigm can exist, and with which specific barriers for integral assessment can be surpassed"* **(hypothesis 2)** (for example, essential *motor symptoms* to provide and evaluate healthcare services to patients suffering Parkinson Disease (PD), *Inspiratory capacities* to treat and assess efficiently pulmonary diseases, etc.).

III. Proposition

Based on our hypotheses and guided by the fact that smart medical devices work in conjunction of advance computing to conform smart systems (composed of local equipment and mutualized infrastructure [11]), we propose in Figure 1 a novel framework for the integral and practical estimation of the positive and negative effects of smart technologies on patients and environment.

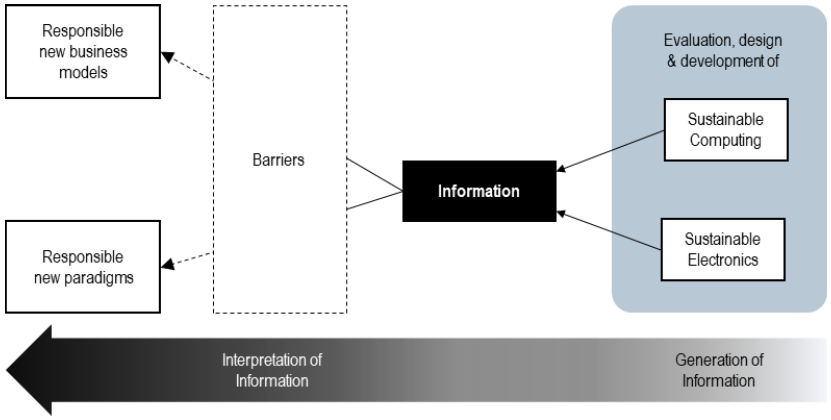

Fig. 1. A novel framework for integral and practical Cost-Effectiveness Analysis of smart technologies in the medical field.

It consists of three parts, operating as follows: In part I, the evaluation, eco design and development of sustainable computing and electronic devices are addressed. In part II, only the sufficient data is collected or defined to generate the *meaningful information* for both, the primary function and the evaluation of medical application addressed by the smart technology. Finally, Part III involves interpretation, which helps overcoming specific difficulties, barriers, and dilemmas that hinder the integral cost-effectiveness analysis and development of new medical devices, business models and paradigms.

IV. Preliminary Estimations, Ongoing Work and Future Research

This framework is been used to estimate, through a back-of-the-envelope calculation, the impact and benefit sides of transforming a commercial inhaler into a "smart" inhaler oriented to track and improve the inhalation technique of patients with Chronic Obstructive Pulmonary Diseases (COPD). From *essential data* characterizing *inspiratory flow* of patients (i.e., *drop pression* detected by MEMS sensors embedded in inhalers), A basic design of the electronic card is established and evaluated according to the Life Cycle Assessment (LCA) methodology. Our preliminary results show a significant increase of the environmental impact in the production phase of the studied device. However, on the basis of an initial simulation of its use phase, a modest increase in drug absorption can be expected from an improved inhalation technique acquired over the course of 4 or 5 years. This encourages us to further investigate not only the potential reduction in drug dosage and the environmental impact mitigation of cartridges production of inhalers in the short-term, but also the improvement in patients' quality of life in the long-term. In this sense, we believe that all our findings will provide clear evidence to challenge our main hypotheses within the field of Health Technology Assessment of digital health and in the context of additional case studies respecting other medical and health fields. The next step is now to demonstrate that the generation and interpretation of meaningful information are critical for the sustainability assessment, design, development, and adoption of digital health technologies and services.

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References

[1] Coravos A, Goldsack JC, Karlin DR, et al. Digital medicine: a primer on measurement. Digit Biomark. 2019;3(2):31-71. doi:10.1159/000500413.

[2] Castle-Clarke S. What will new technology mean for the NHS and its patients? London: King's Fund, 2018.

[3] Kaihlanen, A. M., Laukka, E., Nadav, J., Närvänen, J., Saukkonen, P., Koivisto, J., & Heponiemi, T. (2023). The effects of digitalisation on health and social care work: a qualitative descriptive study of the perceptions of professionals and managers. BMC health services research, 23(1), 714.

[4] Davis J. 32Mpatient records breached in first half of 2019, 88%caused by hacking. Health IT Security website. Published August 1, 2019. Accessed January 09, 2025. https://healthitsecurity.com/news/32m-patient-recordsbreached-in-first-half-of-2019-88-caused-byhacking.

[5] NHS Digital. Digital inclusion for health and social care. 2019.

[6] Black DR., Lanzisera SM, Lai J, Brown RE, and Singer BC. "Evaluation of miscellaneous and electronic device energy use in hospitals." World Review of Science, Technology and Sustainable Development 10.1-2-3 (2013): 113-128. https://www.osti.gov/servlets/purl/1172701.

[7] Global strategy on digital health 2020-2025. WHO. Available on https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf.

[8] Vis, C., Bührmann, L., Riper, H., & Ossebaard, H. C. (2020). Health technology assessment frameworks for eHealth: A systematic review. International Journal of Technology Assessment in Health Care, 36(3), 204-216.

[9] Neri, A., Negri, M., Cagno, E., Kumar, V., & Garza-Reyes, J. A. What digital-enabled dynamic capabilities support the circular 857 economy? A multiple case study approach. Business Strategy and the Environment. 2023.

[10] Quisbert-Trujillo, E., & Morfouli, P. (2023). Using a data driven approach for comprehensive Life Cycle Assessment and effective eco design of the Internet of Things: taking LoRa-based IoT systems as examples. Discover Internet of Things, 3(1), 20.

[11] Quisbert-Trujillo, E. (2022). Design methodology for sustainable IoT systems (Doctoral dissertation, Université Grenoble Alpes).