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The Need for Green and Responsible Medical Informatics and Digital Health: Looking Forward with One Digital Health

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Summary

One Health is an important initiative to view the world in a more integrative sense of our health and environment. Digital Health provides essential support to all of us as healthcare professionals and customers. One Digital Health (ODH) combines both One Health and Digital Health to provide a technologically integrative view. ODH gives an essential place to the environment and ecosystems. Thus, health technologies and digital health must be "green" and eco-friendly as much as possible. We suggest in this position paper examples of developing and implementing ODH-related concepts, systems, and products with a respectful consideration of the environment. For humans and animals, developing cutting-edge technologies to improve wellness and healthcare is critical. Nevertheless, we can learn from One Health that digitalization and so One Digital Health must be built to implement green, eco-friendly, and responsible thinking.

Keywords

One digital Health; one health; digital health; informatics; eHealth; medicine; veterinary medicine; ecology; green computing; sustainable development; environmental monitoring; education; patient engagement; citizen science; data science; smart growth

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Celebrating "One Health" is great, but …

Each year on November 3rd, we "celebrate" One Health day [1] throughout the world. This is an important initiative to give scientists a town square where they can share their challenging questions, research, and understanding of health and environment with the public, under the overarching concept of One Health [2, 3]. Nevertheless, one day per year is insufficient to raise awareness of issues such as environmental pollution and climate change impacting human and animal health, the risk of emerging infectious diseases and viruses associated with the spread of antimicrobial resistance (e.g., reducing the chances of treatment efficiently), or the lack of prophylactic solutions (e.g., vaccines). Population education and engagement are essential to enhance understanding of what One Health is and why everyone needs to take care of themselves, others (i.e., humans and animals), and ecosystems near and far.

…we need to be more digital…

The achievement of the 17 health-related sustainable development goals comprised in the WHO's 2030 Agenda [4] requires the development, to a worldwide extent, of networked infrastructures connecting physical devices with computing systems for data collection, processing, exchange, and analysis, with the scope of addressing critical global health issues, such as antimicrobial resistance, infectious disease outbreaks, and natural disasters.

Developing a correct understanding of what One Health is, means (also) exploring and using digital ways capable of providing the opportunity to develop a consistent approach to "Management of Information, Communication and Knowledge" (or MICK [5]) flows. The scope is to develop and improve communication effectiveness and efficiency between all health-related professionals and consumers (e.g., patients, caregivers, but also healthy people for follow-up and activity tracking).

Digitalization in healthcare means, on the one hand, heading towards 4P (Predictive, Preventive, Personalized, and Participative) medicine for humans and animals [6, 7]. From an environmental viewpoint, it involves accurate real-time monitoring and warning of hazardous events, but also predicting short- and long-term weather and climate change, evaluating the need to develop, update, or replace governance policies and regulations.

Far from being a mere label, Informatics for One Health embodies the will to endow One Health with computational tools to support active prevention and management of zoonotic diseases on a global scale, and aims even more to build an integrative, multi- and inter-disciplinary Public Health approach to understanding communicable diseases [8]. By extension, the One Digital Health [9] framework looks at digitalization:

- on the one hand, as a way to magnify the One Health approach by providing it with an augmented technological workaround, and

- on the other hand, as a systematization of Digital Health by integrating the management of data, information, and knowledge, over the existing humans', animals', and ecosystems' (herein, to be understood such as aquatic, wooded, industrial, and urban) health silos.

. . . and digitalization needs to be green.

Technologies are changing the world. Such a change must aim at improving the quality of life for humans and animals. It demands as well to manage natural resources in such a way that any negative impact is minimalistic and viable, such as supporting health systems that reduce their significant greenhouse gas (GHG) emissions [10]. Therefore, we need to encourage, develop, educate, train, produce, and maintain medical informatics and digital health activities, services, and products for modeling healthcare informatics solutions that are as eco-friendly and green as possible, to get to "green by design" digital systems [11]. These tools are meant to help face the challenges coming with the One Health approach, typically arising from the intertwined human, animal, and environmental spheres, and improving the original autonomy-based idea of Smart Planet [25]. In detail, the tools should allow figuring out and deploying interoperable smart healthcare ecosystems capable of seamless, secure health data exchange and processing.

However, digitization is challenging as it involves the design, development, and production of new systems, services, products, and thus new abilities, competencies, research fields, and practice fields. Even though from this point of view, One Digital Health is looking over the technological and informatics prisms. The combination of the three ODH perspectives (i.e., "individual health and wellness", "population and society", and "ecosystem") and its five dimensions (i.e., "human and veterinary healthcare", "environment", "education", "citizen's engagement", and "healthcare industry 4.0") allows many opportunities to improve and change our personal, professional, and institutional behaviors. These opportunities then provide and obtain better healthcare-related services and products in a more responsible way, and protect and restore the quality of our neighborhood ecotopes and ecosystems.

One Digital Health is a Framework for Eco-friendly Medical Informatics and Digital Health

Thus, implementing a digitization project to somehow boost One Health initiatives cannot be separated from supporting a "green-driven" One Digital Health, whose peculiar features can help to: (i) develop and enhance professional abilities and product features to "think green"; and (ii) work out critical questions such as which potential financial sources will be able to support the different costs at each step, or how to set up the right budget, and for how long.

Education and Human & Veterinary Healthcare

"Providing the right information at the right time at the right place" [12] by the right user (i.e., professional, patient, caregiver), and using the right technology is not trivial.

In this regard, it is essential to educate and train the next generations of healthcare professionals (whoever they may be) and health-related service customers in the use of digital technologies. In first place, it is crucial to train both categories to choose the most suitable technology for a need by considering its short-, mid-, and long-term ecological impact. On the other hand, an important focus must be on engineering and informatics: a lesson in "eco-friendly thinking" of utter importance to be learned concerns, in fact, the awareness of the need to reduce the often (excessively) resource-consuming processes of coding and "ideation-proof of concept".

Enhancing students' education and training allows them to think carefully about algorithm design and validation before coding and running programs. The enhancements can substantially:

- reduce energy consumption,
- slow down the hardware, and thus
- reduce the need to renew electronic components.

In other words, future health informaticians and digital health professionals must return to the basics to reduce ecological fingerprint of the field.

Citizen and Industry 4.0 Engagement

The considerable volumes of data generated by the use of digital services (e.g., websites, applications) and products (e.g., smartwatches, electronic tensiometers, imaging systems), especially in the context of Smart (Healthy) Cities, while witnessing active citizen engagement and participation, now need to undergo a "Smart Choice" process [13, 14] in order to decrease the overuse and misuse of exams (for both humans and animals [15]) and treatments [16], especially if involving health technologies. While, on the one hand, healthcare professionals are already called upon to follow training paths to develop critical thinking about digital solutions in their practice, on the other hand, customers of healthcare services (i.e., patients and their caregivers) also need to learn how to understand advertisements and buy what is actually necessary for them [17].

The industry, which is one of the drivers of medical informatics, has to conduct its current digital revolution, also tackling the One Health paradigm. This means pursuing a commitment to the development of standards and best practice guidelines to realize systems and products (from conception to recycling *via* production and distribution) that cause the least possible impact on the environment - e.g., by looking at optimizing the development of tools designed to consume the least amount of computing time and resources [18].

Environment

Many critical phenomena persist around us. It is the case of e.g., antibiotic resistance - also known as antimicrobial resistance or AMR, as the ability of pathogens to not react to drugs that must eliminate them. Animal and human excrement that contain antibiotics and antibiotic-resistant pathogens are disseminated in natural ecosystems from agricultural, industri-

al, and urban sewage systems. Such pathogens are then found in all natural water resources (from streams to oceans), and first have an impact on the life of aquatic systems by inducing a broad fragilization of aquatic fauna and flora before returning to humans [19].

Monitoring and evaluating the level of risk connected to the impact of AMR on living beings can mainly result, from a One Health's point of view, in an active support role in the prevention, preparedness, response, and mitigation phases, as formalized in the Disaster Management Cycle [20]. Shifting to One Digital Health, the original intentions are somehow "upgraded"—e.g., the capacity to design, develop and use decision support systems - to improve the personalization of the prescription process to reduce the misuse or overuse of broad-spectrum antibiotics with poor outcomes [21]. Even better, developing digital education tools may avoid the unjustified use of antibiotics (e.g., the use of antibiotics for treating influenza) [22].

Conclusion and Take-home Message

The One Digital Health concept blends two existing frameworks under one roof: Digital Health and One Health. This kind of synergy aims to create a functional and dynamic framework to track potential environmental hazards and prevent (if necessary, confront) potential health-related crises that may arise. All this needs to combine the existing methods, infrastructures, and long-term experience stored in health-related platforms (such as Electronic Health Records, Patient Health Records), environmental and ecological monitoring platforms, social media services, the Internet of Things, and more "big data" resources. The main goal of One Digital Health is to provide every relevant scientific community and the grand public with an efficient and straightforward framework for everyone to contribute to and benefit from improvements in assessing and treating health and ecological issues as a whole, in a **FAIR** and **smart** way [23, 24]. In any case, it is critical to keep in mind that, to be "green" and "responsible", all the health-related devices, systems, and processes allowing monitoring, data collection, storage, analysis, and (re)action must be developed in such a way that the ecological fingerprint is as small as possible at every steps.

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